MACHINERY.

March, 1903.

AMONG THE SHOPS.

NOTES OF TECHNICAL INTEREST FROM BOTH EAST AND WEST.

IT has been learned by experience in the construction of vertical engines that the cylinders, especially if they are of large size, should be bored in a vertical position. This is owing to the fact that when a cylinder is placed horizontally a certain amount of settling takes place owing to the weight of the casting and if it is bored in this position and then placed vertically, so that this weight-strain is removed, the result will be an oval hole. As all of the large marine engines are of this type, a vertical boring machine is consequently one of the necessities of a marine engine shop.

The engines for the new battleship "Connecticut," which is now being built at the New York Navy Yard, will be the product of the Department of Steam Engineering connected with the Yard, and will be of the vertical, triple-expansion type, the low-pressure cylinders having a bore of 61 inches. It is for the purpose of boring these cylinders that the Department has designed and constructed the vertical boring machine illustrated in Fig. 1. The extreme height from the bed plate to the under side of the connecting tie is 10 feet 11½ inches, while the width between the upright columns is 10 feet. It is placed upon a bed of concrete which, in turn, rests upon a pile foundation.

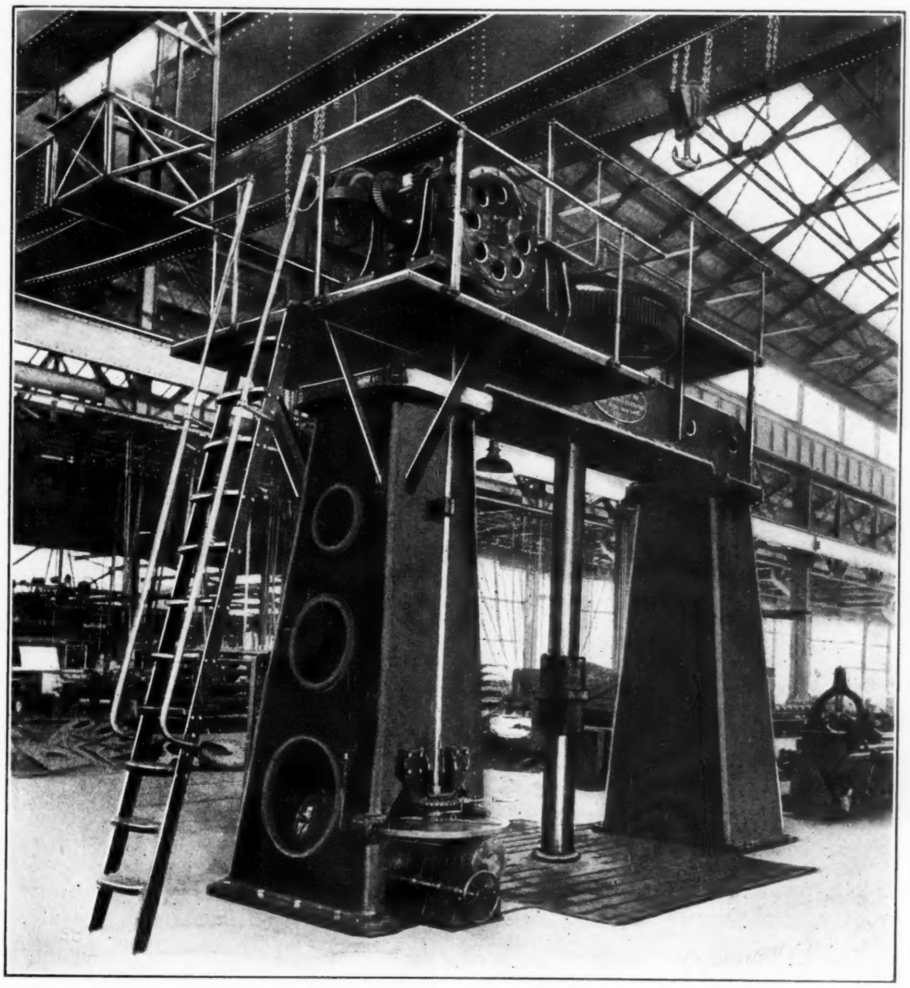

Fig. 1. Large Vertical Boring Machine designed and built at the New York Navy Yard.

The machine is electrically operated, being driven by a Westinghouse, two-phase, alternating current motor of 15 horse power capacity, running at a speed of 720 revolutions per minute. The motor is placed inside of one of the column legs, upon the back of which, at a convenient height, is mounted the switchboard.

Since this motor starts at full speed, friction driving mechanism has been employed and a detail of the motor and friction drive is shown in Fig. 2. The armature shaft is connected by a coupling to the shaft *A*, upon which is mounted the friction driving pinion *B*, so arranged that it may be drawn in or out across the face of the friction disk by means of a screw and hand wheel, thus increasing or decreasing the speed at which the shaft *E* is driven. The pinion *D*, which is mounted on an extension of the driving shaft bracket, serves simply as an idler for supporting the outside of the friction disk and does not move across its face as does the pinion *B*. Both of these pinions are of cast iron, having a circumferential groove lined with leather which runs in contact with the cast-iron friction disk. The disk *C* is withdrawn from the pinions or forced into contact with them with any degree of force by means of the hand lever *F*, which rotates the nut *G* and thus moves the disk up or down. The thrust of the disk is taken upon a ball bearing collar and at all places in this machine where a thrust is encountered ball bearings have been provided.

From the friction disk the driving shaft rises to the operating platform from which all the movements of the machine can be controlled. At this platform the vertical shaft is geared with one placed horizontally carrying a pinion from which is derived the power to operate the system of gearing that is used to drive the boring bar. The web of the first gear in the system is bored out to form a friction clutch so that the driving mechanism may be engaged or released without stopping the motor. Upon the end of the horizontal shaft, above mentioned, is a friction disk from which the feed is driven. A handle, which may be seen at the left of the mechanism, is used for moving the friction pinion to any position across the face of the disk in order to give the desired rate of speed. The direction of feed is changed by shifting the pinion from one side to the other of the friction disk. In addition to the change in feed that is accomplished in the above manner, a set of change gears is provided for increasing the range of feed. At the top of the bar will be seen the two large spur gears by which the bar and feed screws are driven. The lower and broader gear is keyed directly to the bar while the upper one is independent of the bar and

contains an internal gear that meshes with the pinions mounted on the ends of the two feed screws.

Three boring bars, having diameters of 6, 10 and 14 inches respectively, are provided for use with the machine, the 6-inch size being used for boring the stuffing boxes of the large cylinders. The removal or exchange of these bars is easily accomplished by use of one of the electric cranes by which the machine is served. When not in use the bars are stood vertically in a bracket which is fastened to the further side of the right-hand column. For facilitating this handling of the bars an eye bolt is permanently attached to the top of each bar, as will be seen in Fig. 3, which is a detail of the 14-inch bar. Two feed screws extend along opposite sides of the bar and fit bronze nuts in the sleeve which is shown at about the center of the bar. To this sleeve are fastened the different heads that carry the boring tools. At the top of each feed screw will be seen the pinions which engage with the internal driving gear.

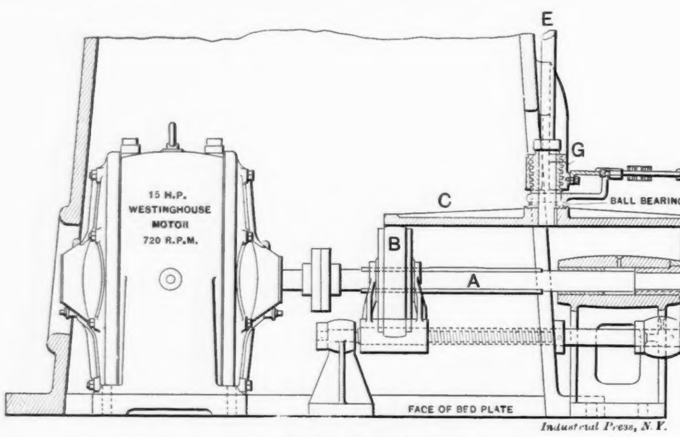

Fig. 2. The Motor Drive.

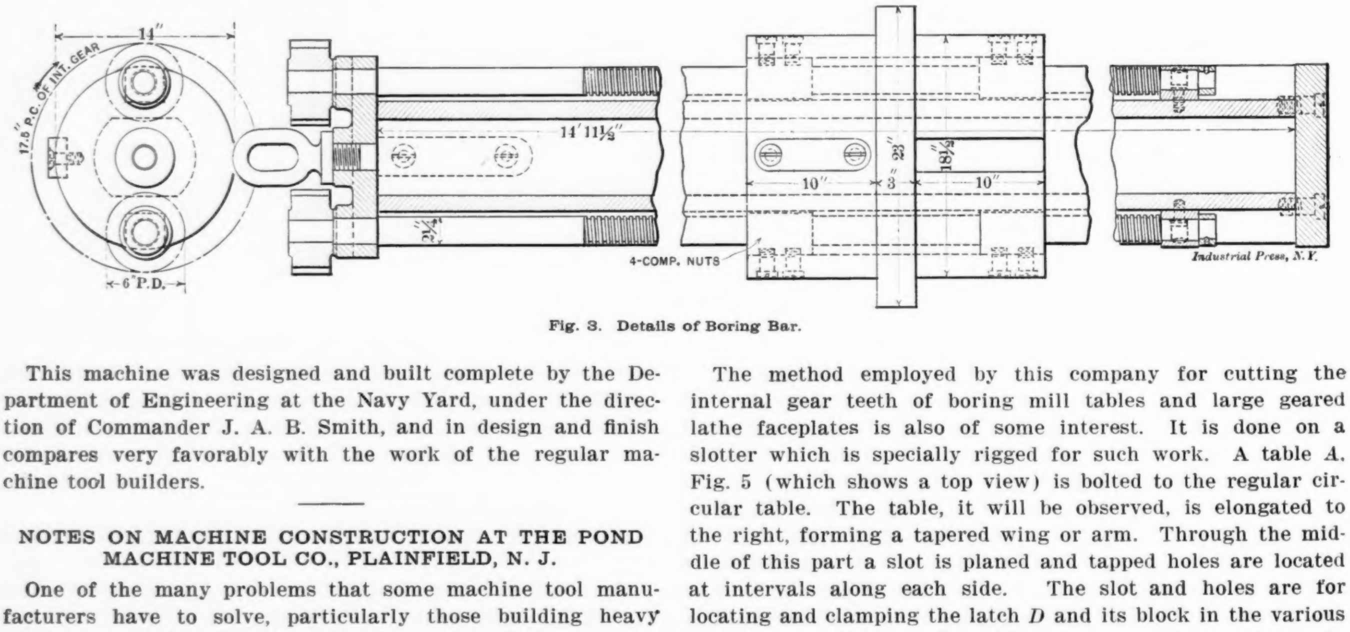

Fig. 3. Details of Boring Bar.

This machine was designed and built complete by the Department of Engineering at the Navy Yard, under the direction of Commander J. A. B. Smith, and in design and finish compares very favorably with the work of the regular machine tool builders.

NOTES ON MACHINE CONSTRUCTION AT THE POND MACHINE TOOL CO., PLAINFIELD, N. J.

One of the many problems that some machine tool manufacturers have to solve, particularly those building heavy machinery, is the economical handling of parts larger than the capacity of their largest shop tools. Again there are machine parts that, for the smaller machine sizes even, are awkward to handle, and which, if treated in the manner that naturally would be followed for the particular operation required, would mean the tying up of shop tools of a capacity all out of proportion to the extent of the operation. That is to say, a large tool might be required to do a machining operation comparatively small in extent and one that would take but little time after the piece was chucked. More time would be consumed in chucking than in the actual operation. This applies with some force to facing the outer bearing rings on the bases of boring mills, large or small.

In the April, 1900, issue we briefly described how Wm. Sellers & Co. bored and turned the bases for the huge 28-foot boring mills built by them for the Westinghouse Companies. In this case a comparatively small boring mill in the shop was stripped of its housings, leaving only the base, table and driving machinery. The base to be bored and faced, was placed upside down over the stripped mill and supported at the four corners on suitable pedestals. A cross rail fastened to the lower mill table carried a slide and tool which did the facing of the bearing ring. This job was, of course, an unusual one and required unusual procedure, but it very well illustrates some of the expedients that often have to be resorted to. In this case something of the kind was absolutely necessary, as there was no boring mill or pit lathe large enough to swing the base.

The method regularly employed by the Pond Machine Tool Co. for facing the outer bearing rings on all their boring mill bases, is well worth a short description. The bases are planed, bored for the table spindles (this is done on a horizontal mill with a boring bar) and, in fact, all the other machine work is done before the bearing ring is faced. The base without the housings is erected over a suitable shop pit, and the driving works and table placed in position. But the table is not lowered to its normal position, being instead supported on its step bearing a distance of four or five inches above it, as shown in Fig. 4. Being driven by a spur pinion meshing in an internal gear, the table may be revolved by power in this position by belting to the cone pulley in the usual way. An angle casting *C*, carrying a slide and cutting tool *D* at its lower end, is bolted to the table *A*. Now by driving the table by power through the regular channel, the bearing ring is quickly and accurately faced and that without requiring a large boring mill for the job. The operator feeds the tool across the cut a short distance for each revolution as the slide comes around to him, and to take a fresh cut he simply lowers the table by means of the step-adjusting screw *B*.

The method employed by this company for cutting the internal gear teeth of boring mill tables and large geared lathe faceplates is also of some interest. It is done on a slotter which is specially rigged for such work. A table *A*, Fig. 5 (which shows a top view) is bolted to the regular circular table. The table, it will be observed, is elongated to the right, forming a tapered wing or arm. Through the middle of this part a slot is planed and tapped holes are located at intervals along each side. The slot and holes are for locating and clamping the latch *D* and its block in the various positions required for the different sizes of index plates, *B*. The internal gear blank, *C*, to be cut, is mounted on the index plate so that, of course, both turn together when indexing. The cutter bar and tool mounted on the slotter ram, are shown at *J*. The tool is relieved on the "up" stroke by means of a compound nut *G* and suitable connections to operate it at the right time. This nut forms the thrust bearing for the feed screw *F* and is externally threaded to fit a coarse thread cut in the base. Turning the nut *G* in either direction, gives a longitudinal movement to the feed screw *F* independent of its regular feed motion. The feed screw is operated from the opposite end and is splined so that it is free to slide longitudinally to accommodate the motion communicated to it from the nut *G*. In this manner the table carrying the gear is moved away from the tool a short distance just as the "down" stroke is completed and back again at

the end of the up stroke without interference with the regular feed motion, which is accomplished by ratchet action in the usual manner. The oscillatory movement of the feed motion is communicated to the nut G by the levers and shaft H.

NEW FOUNDRY OF THE VILTER MFG. CO., MILWAUKEE—HEATING SYSTEM—CHARGING THE CUPOLA.

The Vilter Manufacturing Co., Milwaukee, Wis., builders of Corliss engines and refrigerating machinery, have been occupying a new foundry building for some time past, designed by their superintendent, Mr. Theodore O. Vilter. Before proceeding with the erection of the building Mr. Vilter visited a large number of foundries in different parts of the country and incorporated in his design such ideas as he believed to be of practical value to a concern engaged in heavy engineering work. The foundry is 280 by 110 feet in area and is served by two Pawling & Harnischfeger cranes, one of 30-ton and one of 15-ton capacity and both of 60 feet span. The building is arranged in three bays, with monitor roof over the middle bay. The side walls have windows extending nearly from floor to roof, the openings being as large and as near together as considerations of strength will allow. The walls are of brick laid to form pilasters about 20 feet apart. The pilasters encase steel columns which support the roof, thus making it necessary for the walls to be self-supporting, merely, and allowing a much greater window space than if the walls had to be built to sustain the weight of the roof. The sides of the monitor roof have windows for lighting the central portion of the building and for providing ventilation. These windows are all connected with rock shafts that can be operated from the floor and may be conveniently opened or closed as often as required to keep the air pure and free from smoke.

The building is heated by the forced blast system, air being drawn in from the outside and forced over steam coils and thence through ducts to different parts of the building. In the arrangement of the ducts, however, an important departure has been made from the usual arrangement of sheet iron pipes commonly employed in manufacturing establishments for conveying the warm air to the different departments. The passage for the air in this case consists of a bricked-up subway extending along the two sides of the foundry, close to the foundation walls, and below the floor level, with a connecting passage running from one side to the other at a distance of about 25 feet from one end of the building. The heating coils and blower are situated near the center of one side of the building and the air is delivered to this underground duct and escapes to the interior of the foundry through registers or gratings at suitable intervals. In Fig. 6 are two sectional views of the duct, one taken at a point where it passes one of the pilasters and the other through the passage connecting the ducts on the two sides of the building. The advantage claimed for this arrangement is that it delivers the heat where it is wanted, viz., next to the cold walls, and that as the hot air enters from or near the floor level it meets and warms any cold air descending from the windows or outer walls and so prevents drafts and maintains a uniform temperature throughout the structure. The top of the duct is covered by cast iron plates, any of which may be removed and gratings substituted. The connecting passage is entirely below the floor level, and is covered with plank and boards, with a layer of paper between and with several inches of foundry sand on top.

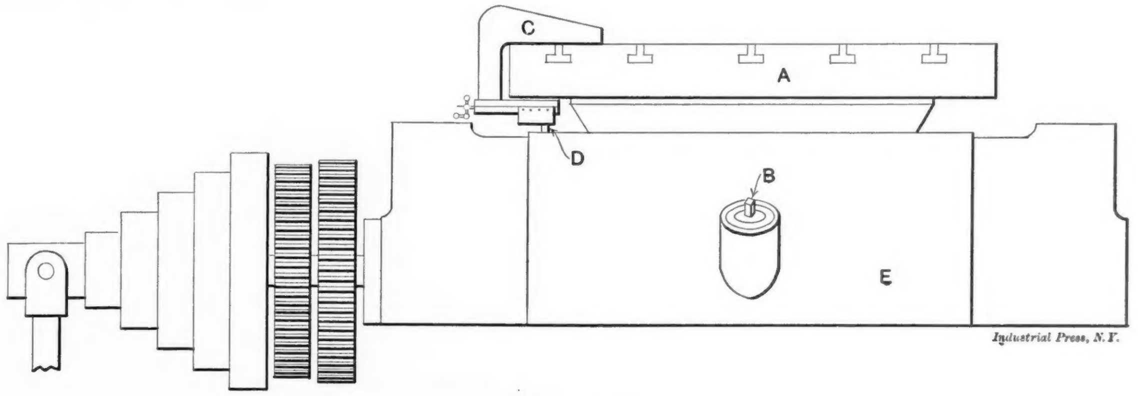

Fig. 4. Method of Facing the Outer Bearing Rings of large Boring Mills.

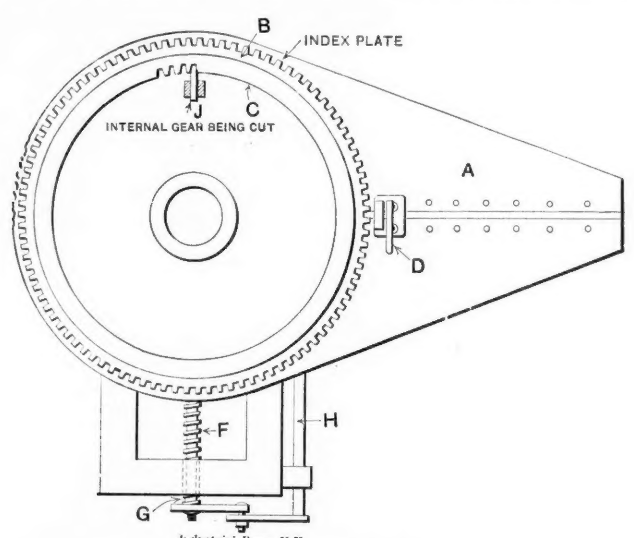

Fig. 5. Cutting Internal Gear Teeth of Boring Mill Tables.

In Fig. 8 is shown the arrangement of the two cupolas, blower room, etc. The main, or outer wall of the foundry is at A, A, and at B, extending both into and outside of the foundry is the cupola room, which is bricked up and provided with doors by which it can be shut off from the foundry, to keep out the dust when dropping the bottoms of the cupolas. The cupola room is two stories high, the upper, or charging floor being of steel. Next to the cupola room on one side is the blower room, containing a Roots blower, driven by a steam engine. The engine is used in preference to an electric motor for this, because it is necessary to vary the speed of the blower to adapt it to either or both cupolas, or to differ-

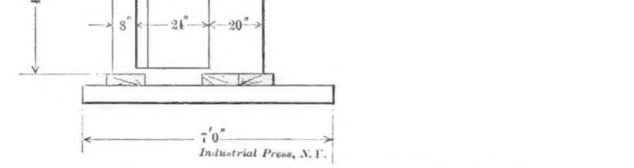

Fig. 6. Heating Ducts of Foundry, Vilter Mfg. Co.

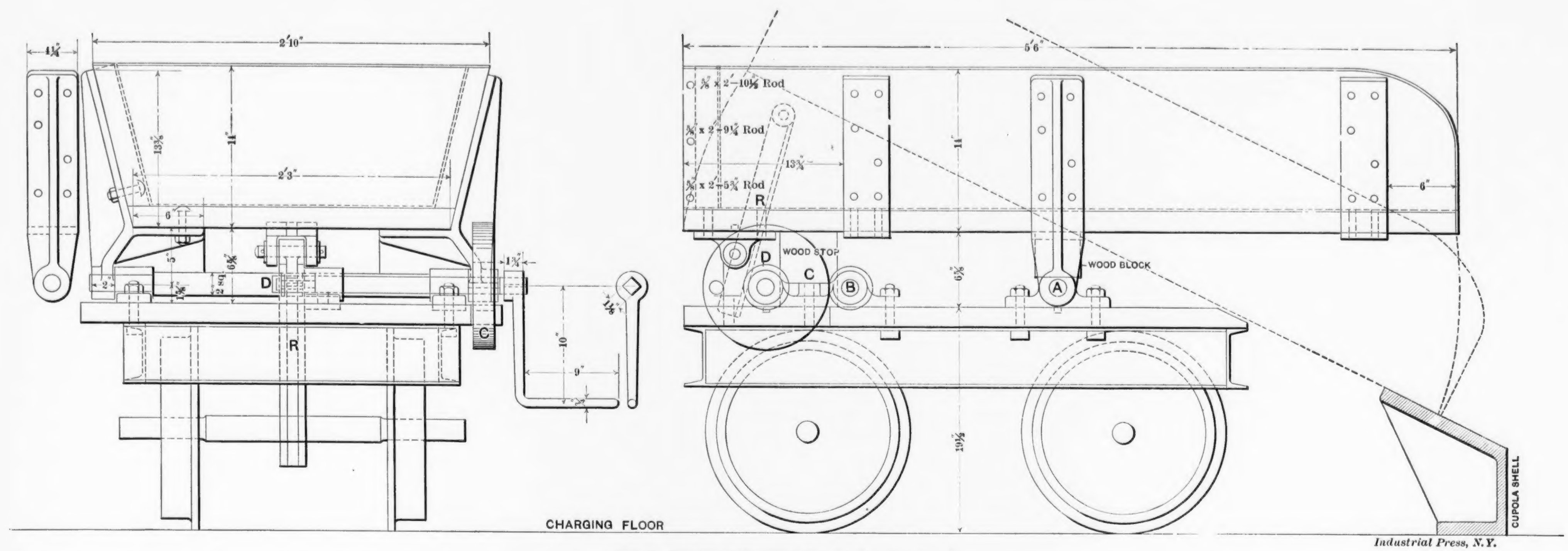

Fig. 7. Details of Charging Car for Foundry Cupola.

ent charges. Directly over the blower is the heating apparatus in which the fan is motor-driven. At night, if there is no current available for operating the motor, the engine can be disconnected from the Roots blower and used to operate the heating fan. On the other side of the cupola room are the lavatory and closets. Several sand sheds are built along the outer wall to the left, Fig. 8, outside of the building, one of which is indicated in the plan.

In charging the cupolas, a car bearing the pig or scrap iron and coke is pushed along the track *T*, *T*, to a pneumatically-operated elevator in the corner of the cupola room and raised to the c h a r g i n g floor. There it is wheeled off onto the turn-table *K*, and by its aid is aimed toward the charging door of one of the cupolas, when it is pushed off onto the charging floor. When the charge is wanted its journey is continued to the cupola and the load dumped.

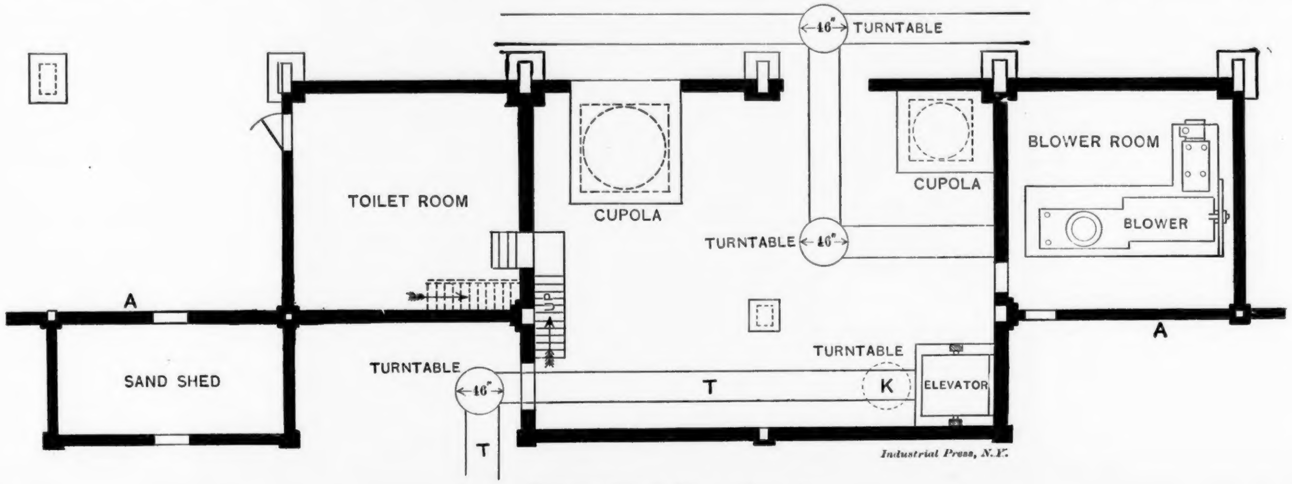

Fig. 8. Showing Cupola Room of Foundry.

The charging cars were designed by Mr. Vilter and are shown in detail in Fig. 7. The framework of the truck is of channel iron beams, to which are bolted the bearings for the wheels and supports for the body. The body is of two-inch plank, lined with sheet iron and is pivoted a little back of the center by means of suitable supporting arms, which have a bearing on two pins, one on either side, and held by brackets, *A*, bolted to the frame of the truck. The pivot arrangement is for the purpose of dumping the charge into the cupola, and the body is tilted up through the gearing at the rear of the truck, operated by the wrought-iron crank shown in the left-hand view. The pinion *B* is on the crankshaft and meshes with gear *C*, which is on a shaft extending to the center of the car. On the inner end of this shaft is pinion *D*, which meshes with rack *R*, attached to the body. The

rack is shown dotted in the right-hand view and in the position in which it is indicated the car body would be raised so as to dump the charge. The pinions *B* and *D* have 15 teeth, ¾-inch pitch each, and gear *C* has 45 teeth. There are several of these cars, so that a sufficient quantity of material may be accumulated on the charging floor without any re-handling, such as would be necessary if the cars had to be unloaded before charging.

At one end of the foundry are the core ovens, with which the foundry is well provided. There are five ovens, ranging from 26 feet 6 inches by 20 feet 6 inches by 14 feet high to 4 by 5 feet and 6 feet high. The two largest ovens have two tracks for running in the trucks carrying the cores, and the next smaller has one track. All the furnaces for the ovens are depressed four feet below the floor level and project above the floor level on an average about two feet. The largest oven has two furnaces, with grate areas 2 feet 6 inches by 4 feet. The next oven has one furnace, with grate 3 feet by 5 feet. A passageway extending along the rear of the ovens is depressed four feet to correspond with the level of the furnaces and all the furnaces are located so they may be fired from the passageway.

The feature of the ovens most appreciated by the workmen, however, is the arrangement for raising and lowering the doors. The usual spectacle of half-a-dozen workmen trying to raise a hot iron door 10 or 15 feet square is not experienced here. At the rear of each furnace is a long cylinder in which there is a plunger operated by the compressed air system of the foundry, by which the doors are raised and lowered through cables which pass over sheaves and connect with them. The cylinders are in all respects like those employed for pneumatic hoists, and operate on the same principle.

NORTHERN ELECTRICAL MFG. CO., MADISON, WIS.—LARGE POWER PRESS ELECTRICALLY DRIVEN.

The Northern Electrical Manufacturing Co., Madison, Wis., have in use at their works an electrically-driven hydraulic press, two views of which are shown herewith. The machine was designed by their superintendent, Mr. T. E. Drohan, to meet the special requirements of dynamo and motor manufacturing and was built at the Northern Electric shops. The chief work for the press is compressing the laminated sections of which the armature cores are built, preparatory to bolting them solidly together, but it can be used equally as well for forcing mandrels into hubs or for any of the work of this character that must ordinarily be done around the shop. Small or large work can be handled with equal facility.

The press consists of two parts, the press proper, shown at the right in Fig. 9, and the operating and controlling mechanism on the stand at the left in the illustration. The press proper has the usual corner screws as its "backbone." The pressure is applied by two hydraulic cylinders and plungers, under the platen, or lower head, and on the floor level. The four corner screws are four inches in diameter and are rigidly connected to the cylinder casting at their lower ends, and support the head at their upper ends. They also serve to guide the platen in its vertical motion and prevent any "side wind" if the loading should be eccentric.

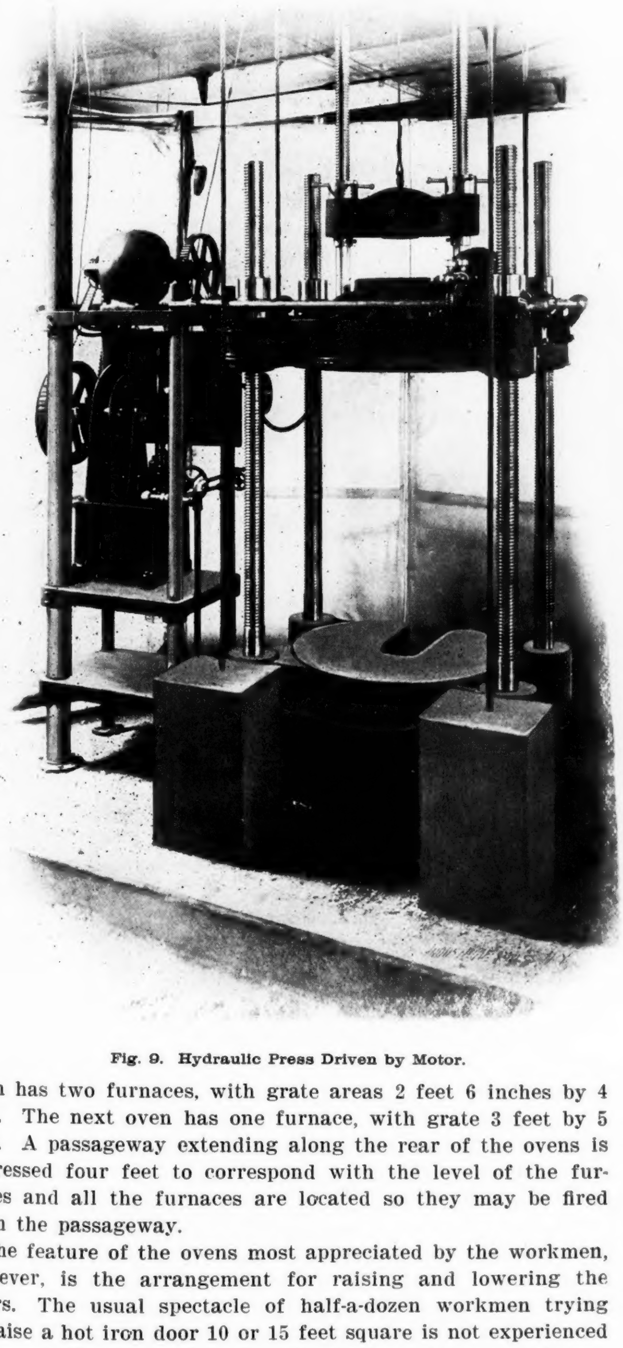

Fig. 9. Hydraulic Press Driven by Motor.

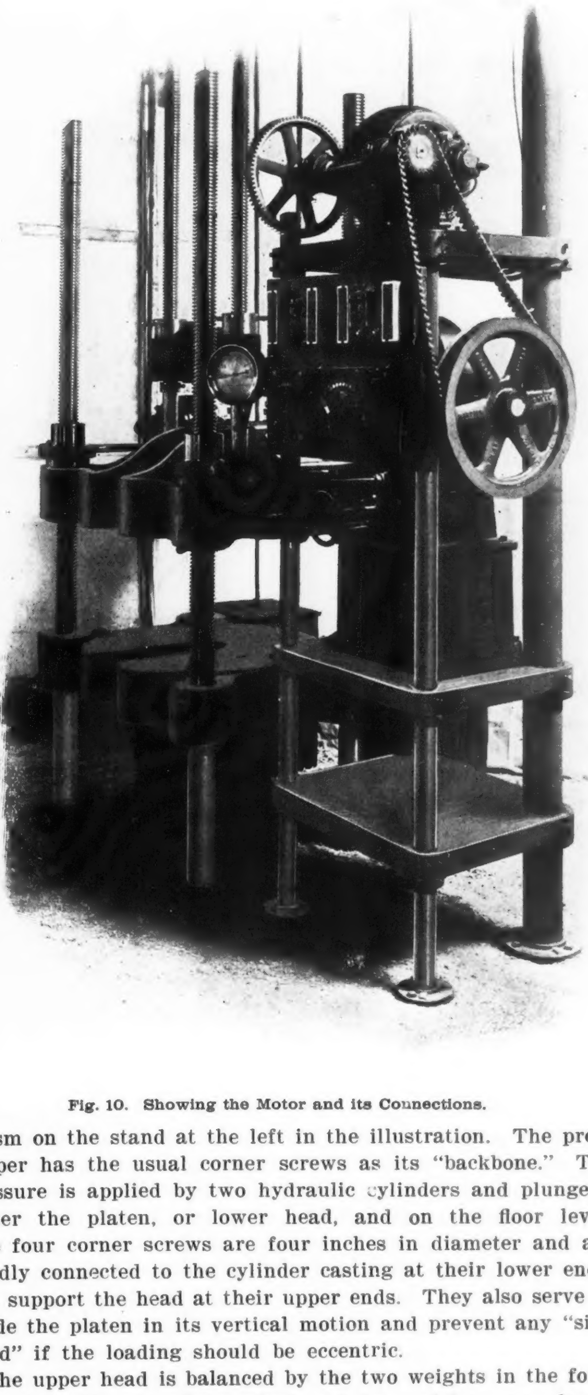

Fig. 10. Showing the Motor and its Connections.

The upper head is balanced by the two weights in the foreground in Fig. 9 and is raised and lowered by a one horse power electric motor placed on top of the head casting. There is a cylindrical nut supported by a bearing in each corner of the head which is so held that it can have no endwise movement, but which may be rotated by power in either direction to raise or lower the head, as required. The method of rotating these nuts is by the horizontal shafts extending around

three sides of the head and which are plainly visible in both views. Each nut has spiral gear teeth cut on its outer surface which mesh with gears on the horizontal shafts. The connection between the three shafts is by bevel gears, so that they all move in unison, and they receive their motion from the motor mentioned, through a worm and worm gear.

In designing this press the idea was to use standard apparatus, as far as possible, and to arrive at the desired result by grouping these units. While certain parts like the heads and screws were special, the motors, controlling apparatus, hydraulic pump, etc., were all standard. The latter is one of the regular pumps manufactured by the Watson-Stillman Co., New York, and is chain-driven by a 2 horse power motor placed on the upper shelf of the stand, directly over the pump. At the front of the stand is the controller board which contains the switches and starters used for starting, stopping and reversing the motors.

The time-saving feature of the machine is obviously the power adjustment for the upper head. As the head can be brought down to the work by power without any effort on the part of the operator, the time and labor that would ordinarily be expended in blocking up the work or in moving the head by hand is thus saved.

Both the upper head and lower head or platen are slotted on one side to allow the passage of an arbor or shaft which is being pressed into or out of a piece of work. For very long work of this character there is a supplementary head, Fig. 9, p. 341, consisting of a stiff casting supported by two screws extending upward from the main head of the machine. This cross piece is moved up or down by hand adjustment.

The press has a maximum capacity of 400,000 pounds.

* * *

A novel feature of the equipment of the San Francisco fire department is a steel drill tower for practice purposes. This tower is four stories high and has fire escapes down the outside, like those of a building, and is provided with a standpipe such as are now to be found in all modern structures for business purposes. On certain days a number of firemen are detailed to practice with scaling ladders, water towers, fire escapes, etc., and the time required to connect the hose with the standpipe and play a stream of water upon any one of the floors is taken.

* * *

The time balls located in New York, Philadelphia, Boston and other important cities are operated at the moment when the ball falls by an electrical impulse from the naval observatory at Washington. A short time ago a time-ball apparatus was erected on the top of the Ames building at Boston, and the following description is from the *Boston Globe*.

"The time ball is 47 inches in diameter and is composed of a large number of ribs of brass covered with canvas. On the top of the Ames building is a circular shelter house containing the hoisting drum and electrical mechanism for releasing the ball. On top of this is a steel cylinder, five feet high and 50 inches in diameter, into which the ball falls when released and where it remains until hoisted the next day. The ball slides up and down upon a mast of 4-inch pipe, rising 41 feet above the shelter house. At 11.55 A. M. every day the ball is hoisted to the summit of the mast, and at exactly noon it drops. If the wires are interrupted or any other accident happens, to prevent the drop of the ball at noon, it will be lowered slowly by hand at 12.5 P. M. On Sundays and holidays the ball will not drop.

"While the electrical impulse releasing the time ball comes directly from Washington the electric current is relayed, as it were, at the electrical office of the hydrographic department, in the basement of the custom house. Here a telegraph relay and sounder have been put in, and every second is ticked out over the sounder, with the exception of the 29th, up to 11:59:-49, when the ticking ceases and the attendant on duty opens the switch connecting with the magnet in the shelter house on the Ames building roof.

At precisely noon the electrical impulse comes through from Washington, operates the releasing mechanism and the time ball drops."

THE THERMIT PROCESS.

REPAIRING CASTINGS AND WELDING WITH THERMIT—A PRACTICAL PROCESS WITH GREAT POSSIBILITIES.

FRANK C. PERKINS.

The metallic mixture known as thermit was discovered by Dr. H. Goldschmidt, and is used in certain processes for obtaining intense local heat up to 3,000 degrees Centigrade (5,400 deg. F.) and at the same time producing molten iron having the qualities of a very mild steel.

Thermit is a mixture of aluminum and oxide of iron in chemical proportions and is produced by the Allgemeine Thermit Gesellschaft of Essen-Ruhr, Germany. It is used extensively abroad for welding and repairing of cast iron. At the works of the Cockerill Company, at Seraing, Belgium, thermit was used for the welding of broken cast iron roller-mill bosses, and Mr. Th. Moulan states that besides other tests of the repairs under hammer, the repaired rolls stood the changing torsion that such rolls are subjected to. The welded rolls were used for the purpose of rail production and were reversible. It has also been stated by Mr. W. Hugo, of the Aktien-Gesellschaft Phœnix-Eschweiler-Aue, that a roller-boss welded by the thermit process after rolling 198½ tons of material, broke at a point some 7 inches from the weld, and from the appearance of the fracture the break was not due to the welding process that the roller had been subjected to. This process has been employed for welding together iron tubes for use in freezing plants and overheated coils, with great satisfaction in Denmark, at the works of the Aktieselskabet "Atlas," in Copenhagen, and it has also been ex-

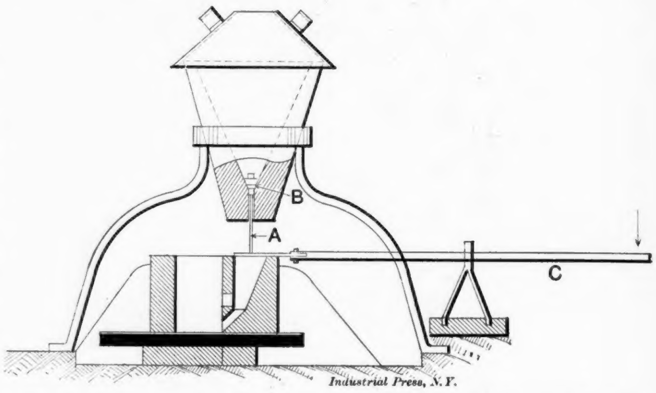

Fig. 1. Typical Form of Crucible used for Thermit Welding and Casting.

tensively used for welding iron tubes in the machine works and foundry of the Hallesche Maschinen Fabrik and Eisengiesserei, of Halle a/s, Germany.

Thermit gives off iron of a very high temperature, about 5,400 degrees Fahrenheit, the resulting iron being exceedingly pure, and with a tenacity equal to very mild steel, so it is obvious that thermit is most valuable for a number of purposes to every foundryman and engineer. For instance, by its aid faulty castings can be made faultless; bosses can be cast on steel or even wrought iron, and broken shafts and wheels repaired. The thermit iron has the property of melting the cold surfaces of the metal it touches, and uniting with it to form one solid mass. Thermit iron produced in a special crucible remains at the bottom of it, and is covered by a layer of three times its bulk of slag. There are two methods of extracting the molten iron out of the thermit, after the reaction has taken place. Either the slag can be poured off first, or the iron can more easily be let off first by an opening in the bottom of the crucible, which opening must not exceed a certain diameter. The crucibles are of varying size, to contain from about 2 pounds up to 200 pounds of thermit, and even more. The whole bulk of thermit is put into the crucible at the same time, and is set alight by adding a thimbleful of ignition powder, and applying a fuse. The whole contents melt down within a few seconds. The

A brief description of the Thermit process, published in MACHINERY some time ago, previous to its introduction in this country, aroused considerable interest among our readers and led to numerous inquiries. We are glad, therefore, to be able to give so complete an account of this interesting development in thermo-chemistry in this number.—EDITOR.

opening at the bottom of the crucible is closed by a small round piece of sheet iron of the size of a dollar, on which is pressed about ½ inch of fine dry sand. When the reaction is complete, the sheet iron plug is driven up by a pin placed in such a position below it that, although it does not touch the plug, it can easily be forced up by a simple lever. The thermit iron issuing from the bottom of the crucible flows into a runner in the mold in such a manner as to rise up again in the mold. The slag which follows can be diverted through an opening, arranged at the side of the runner, at a point about the highest level desired in the castings.

The thermit iron has such a high temperature that a certain proportion of iron punchings, free from grease, can be mixed with the thermit which still retains its property of attaching itself to the metal with which it comes in contact. The quality of iron punchings varies according to the quantity of thermit used. Where only a few pounds are used, no iron punchings should be added. For quantities of 10 pounds or more, the proportion of punchings may be 5 to 10 per cent. and for quantities over 25 pounds up to 15 per cent. may be added. To improve the cast, a very little, say ½ per cent. pure manganese is added, which may be mixed with the thermit, but the best way is to put it into the mold. The surface of the metal to be operated upon must, of course, be properly cleaned free from rust and grease, but not necessarily bright. It should then be warmed, just too hot to hold, or even to a dull, red heat, but never more. Iron can be

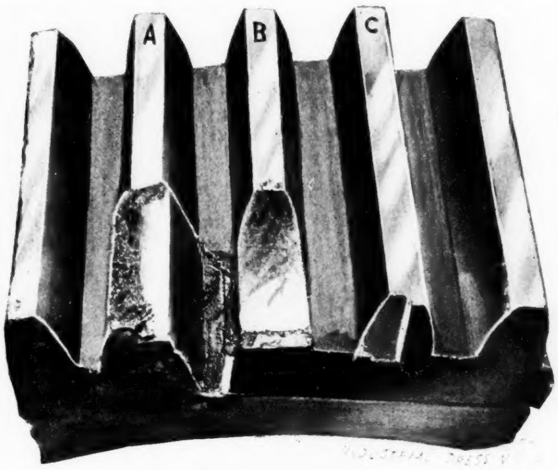

Fig. 2. Illustrating Repair to Broken Gear.

joined to iron, as lead is soldered to lead. This process is called "thermiting," and is applied to girders, bars, angles, in fact any section of rolled or wrought iron, or steel. In all these cases a special mold is required.

Where a mild steel casting is wanted in a hurry, it can be readily made by using thermit with 20 per cent. of small punchings or pieces of thin charcoal sheet iron added. This is run into the mold in the usual way, no furnace or cupola being required.

In welding two pieces of tubing 2 inches inside diameter and ¼ inch in thickness, two sheet-iron molds are employed to inclose the tubing with sand, in order to prevent bad results in consequence of incorrect shape. The two pipes are closely pressed together by the clamping apparatus, the mold fixed, and surrounded by fine damp sand in the surrounding sheet-iron box. Two and one-half pounds of thermit are then measured out, ignited as directed above and the contents of the crucible quickly poured into the mold directly after the surface is free from floating black particles. After about 1¼ minutes the clamps are tightened and the welding is effected.

Pipes of even thickness are most suitable for being welded. Pipes showing differences in thickness of 1-16 inch or even 1-32 inch cannot be operated upon by the thermit process without special precautions being adopted to get an even heat on both sides, which experience alone will teach.

For welding thermit iron on castings and wrought pieces, the apparatus is arranged as shown in Fig. 1, on the preceding page. The small iron pin *A* must be cut down to the required length, the asbestos washer and the small round iron plate *B* placed in position, and the tap-hole well covered up by a thin layer of magnesia, which must be pressed down a little. After this, the manganese, and then the thermit are poured into the crucible, then a thimbleful of ignition powder is thrown in a little heap on the thermit, which is ignited by means of an ordinary fuse. As soon as the reaction is complete, the handle of the lever *C* is pressed down, which will lift the pin in the tap-hole and allow the molten mass to flow out—first the iron, and then the corundum (or slag).

It is said to be advisable to let the welded pieces cool down gradually, and to warm large pieces, before the operation is commenced.

The accompanying illustration, Fig. 2, shows a section of a gear wheel, showing one tooth *C*, on the right repaired and machined, another in the center *B*, broken ready to be mended, and a third on the left *A*, mended but not machined. These teeth are 2½ inches in depth and 6 inches long. It is stated that demonstration on the use of thermit will be made in this country soon for both the welding of rails and tubes, as well as the repairing of castings.*

On electric railways various methods of bonding rails are used for obtaining a good return conductor through the track, as it is desirable to secure such complete and permanent electric continuity as to prevent the leakage and loss of current which often creates great damage to water and gas pipes by electrolysis. In addition to obtaining good electrical contact between the rails, it is also desirable that the joints be nearly perfect in order that the car will not be jarred as the wheels pass over the joints. Electric welding has been extensively used with great success, and produces a perfect joint between the rails, although somewhat expensive. The welding of rails of trolley lines by means of thermit has been quite extensive in Germany and will without doubt be introduced in England and in this country at an early date. Thermit is a metallic mixture of aluminum and oxide of iron in chemical proportions, as mentioned above, and its action is particularly well adapted to welding of rails.

Director Paul Clauss, of the Dresdener Strassenbahn, has stated that the total number of welds made on one kilometer of tramway in Hechtstrasse, only about 1 per cent. of the actual welds were broken, and he states that the welds are harder and not softer than the adjoining iron, while the time required for making the weld between the rails is not longer than that of fixing an ordinary fish-plate.

The thermit welding process has also been employed by the Strassen-Eisenbahn-Gesellschaft of Brunswick, and Mr. Herkt. Lichtenberg states that the cars which are of the accumulator type, weighing each 7 tons, operate upon the welded road without the slightest jolting, and that the welding has been utilized to advantage upon two of their lines—one a quarter of a mile, and the other half a mile in length—the first track being laid upon macadam foundation with ordinary pavement; and the second track on a cement foundation with asphalt pavement.

There are two ways of emptying the crucible; one by pouring out from the top, the second by drawing off from the bottom. In the first case, the slag flows out before the iron; in the second, the iron before the slag. The nature of the application determines which of these methods has to be adopted:

1. Pouring the Slag First.—The slag cooling far more rapidly than the iron, deposits a thin layer on the object it touches, which is thus protected from contact with the molten thermit iron that follows. The latter can, therefore, be applied to hollow iron objects without melting them through or adhering to them. It is especially useful for welding wrought iron or steel pipes, which, on account of the simplicity of the process, can be done in place. All that is required is to clean the welding surfaces, place a mold round the joint, and pour the contents of the crucible. In this way some 50,000 joints of all sizes have been made in the last few months. The weld once made requires no repairs, and stands as high a pressure as the pipe itself. Angle irons and bars of other

* These demonstrations have been made since the first portion of this article was written.—EDITOR.

sections can be equally welded in this way, the result being a clean butt weld.

2. Tapping the Thermit Iron First.—The chief merit of this application is that the thermit iron flows out at such a high temperature that it melts the surfaces of the metal it comes in contact with and amalgamates with it, so as to form one homogeneous mass of mild steel. It has, therefore, been largely used for welding tram rails, repairing faulty castings up to any size, and many other purposes which will at once occur to any engineer. In this case the metal is drawn off through a small opening in the bottom of the crucible provided for that purpose. When the reaction is complete, merely pressing a lever forces up a plug, which allows the metal to flow out; the slag follows. The molten thermit iron round the joint can be of any desired thickness, and in the case of rails takes the place of sole plate and fish plates, with this difference, that it is welded on.

3. For Some Purposes no Crucible is Required.—For example, where a large roller boss is broken off, the roll is placed on end, a mold formed above it, about ½ inch of molten iron is poured onto the broken surface, and thermit added at the rate of about 30 pounds to the superficial foot. It is ignited with the help of ignition powder, except in the case of hot liquid steel, the best of which is in itself sufficient to effect the ignition. Cast iron or steel in sufficient quantities to form the new boss are then added and well stirred. Cast iron can be united with steel, and steel with cast iron.

The process is also used to superheat, as well as to render extremely fluid, both steel and cast iron by adding between 1 and 6 per cent. of thermit, according to requirements.

In addition to thermit as described above, Dr. Goldschmidt has found that specially advantageous results can be obtained by a combination called "Titan thermit." This is added to cast iron in the ladle, where extra tough, fine-grained iron for cylinders, etc., or malleable iron is required. It also tends to increase the fluidity of the run. The quantity required varies from 0.25 to 1 per cent. The process has also the advantage of producing certain metals for alloys in a very pure state and free from carbon. So far this has not been possible even in an electric furnace. The most important of these are chromium and manganese. The former is largely used by gun, ammunition, armor plate and tool steel manufacturers; the latter, especially for copper, tin and zinc alloys (besides nickel and britannia metal). The usual proportions of added manganese for bronze and nickel is 2 per cent.

The production of corundum is, finally, another branch of the process. It is known as "corubin," and is a peculiarly hard and sharp form of emery, the applications of which are numerous and well known.

Demonstration of Thermit Process in America.

The accompanying illustrations, Figs. 3, 4, 5 and 6, show the apparatus used in a recent demonstration of the thermit welding process at the hydraulic works of Henry R. Worthington, in South Brooklyn. The demonstration was under the direction of Clarence B. Schultz, American representative of the Allgemeine Thermit Gesellschaft. The crucible used in welding of rails noted in Fig. 3 was filled with about 16 pounds of thermit and a small quantity of superoxide of barium placed on the top and started with a match. Immediately the most marvelous chemical reaction (Fig. 4) took place, raising the mass to a white heat, the aluminum slag floating upon the thermit iron. The iron was tapped off from the bottom, passing into the mold below and melting the steel rails at the joint, forming a perfect weld.

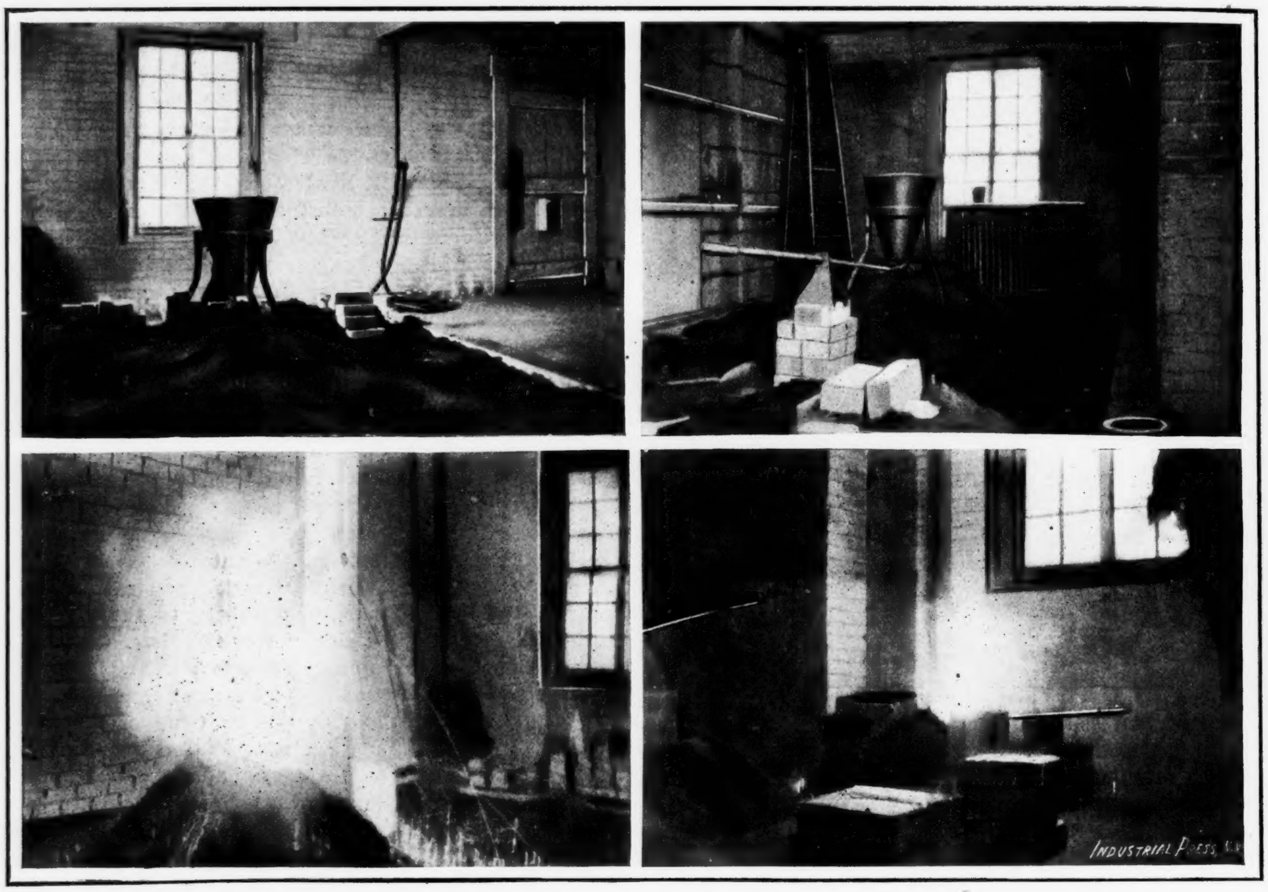

Fig. 3. The Crucible and Mold ready for Butt-welding Steel Rails.
Fig. 4. The reaction during which Alumina Oxide and Thermit Metal are produced.
Fig. 5. Another View of the Crucible showing the Tripping Lever.
Fig. 6. Reaction in an open Crucible for Top Pouring.

It is said that the uniting of the aluminum with the oxygen of the oxide of iron is so terrific that for every kilogram of thermit 1,270 horse power in heat is developed or about 10,000 horse power in the welding of the two rails.

The smaller crucibles were used for the reduction of manganese, as well as for the welding of two-inch iron tubes. The welding being practically perfect, a small quantity of thermit was started as mentioned above, the barium acting in a similar way to magnesium or flash light powder for starting the chemical reaction. Instead of running the metal first from the bottom of the crucible as in welding the rail above mentioned, the slag was poured into the mold first from the top

of the crucible, thus coating and protecting the iron tubes to be welded from the fierce heat of the liquid thermit iron, by the slag. When the proper time had elapsed the tubes were compressed a trifle by the screws, and after the mold was removed the aluminum slag and thermit iron were easily knocked off, leaving a most beautiful weld, the junction being noted only by a single fine line about the tube. Continuous hammering and bending of this tube when cold only produced cracks and breaks at other points than at the weld which was the strongest portion of the tube.

The manufacture of manganese from manganese thermit was also demonstrated, and the repairing of castings by this process is most interesting.

* * *

THE USE OF THERMIT FOR REPAIRING.

To supplement Mr. Perkins' interesting article on thermit, we have secured, through the courtesy of Mr. C. B. Schultz, three photographs just received from Europe, showing two heavy marine repair jobs recently made there, by its use. One was the mending of a broken rudder quadrant of the steamer *Assyria*, Hamburg-American line; the other, a broken crankshaft of a sidewheel steamer plying on the river Rhine.

The steamer *Assyria* arrived at her dock in Hamburg in the evening of November 27, 1902, with her rudder quadrant arm cracked about four-fifths of the way through. Notice of the damage had been telegraphed ahead so that a mold could be prepared at once from the blueprints of the steamer's steering

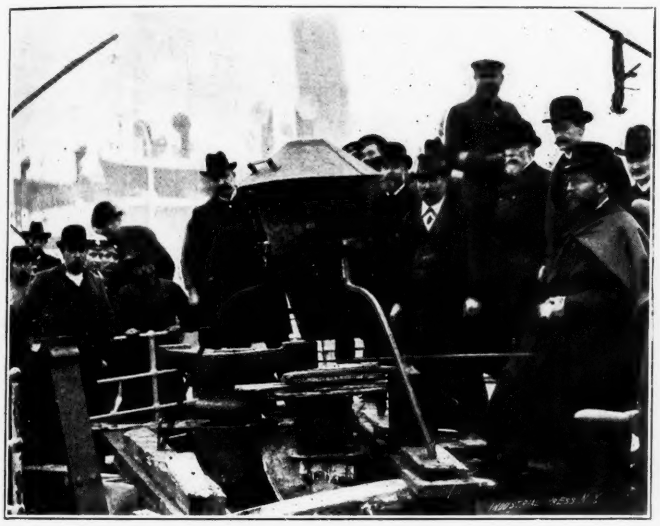

Fig. 1. Set-up of the Crucible and Mold for removing Broken Rudder Quadrant of the "Assyria.

gear. That night the arm was chipped out along the crack so as to make a channel or fissure about ¾ inch wide to the full depth of the crack. The opening thus made, was to allow sufficient body of the thermit to penetrate to the opposing faces to effect a perfect weld, the thermit metal remaining in place and acting as a connecting link between the two parts. The section of the arm at the break was about 4¾ by 8¼ inches. The next morning the arm was warmed up by means of two Bunsen gas burners, to a moderate temperature, and then the mold, which had been prepared beforehand and thoroughly dried, was fitted in place. Where it fitted the arm, the line of juncture was closely luted with clay all around. The quadrant was, of course, supported so as to prevent deflection when heated by the thermit, but it was not removed from the rudder stem, nor was any other heavy part of the steering gear dismantled.

At 12 o'clock everything was ready and the thermit was set off in the cone-shaped crucible shown in Figs. 1 and 2. The crucible was set somewhat higher over the mold than usual, in order to clear the crosshead on the rudder stem. Fig. 2 shows the thermit metal running into the mold. At 1.30 the mold was removed, revealing a perfect job in every particular. At 2 o'clock the steamer was ready to sail. The amount of thermit used for this repair was about 200 pounds.

The repair job shown in Fig. 3 was accomplished about two weeks before the repair to the *Assyria*. The crankshaft of one of the large Rhine sidewheel steamers belonging to the firm of Schurmann Sohne in Ruhrort, was cracked close to the crank. The shaft at this point is about 13¾ inches in diameter and was cracked nearly one-half way through. In this case, also, the metal was chipped out at night, making a fissure about 1⅛ inches wide for the entrance of the thermit between the two faces of the crack. The mold had been prepared beforehand from a hand sketch so that it was all ready when the channel had been chipped out. The shaft was

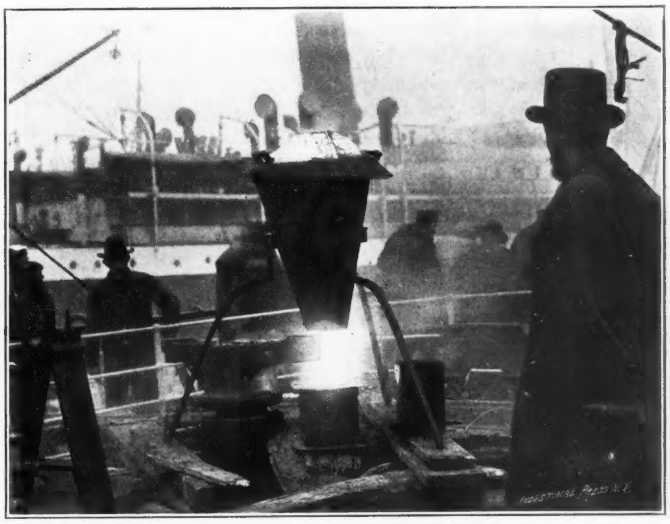

Fig. 2. Pouring the Thermit into the Mold.

tightened down in its bearings and propped up, to prevent deflection and imperfect alignment. The next morning a ring of thermit 2 inches by 4 inches was cast around the shaft, making a perfect union of the parts, the time required for the actual operation being about one minute. The steamer went on her regular trip the same day the shaft was repaired, without experiencing any trouble from hot bearings or other causes. The photograph showing the repaired shaft, was taken after the steamer had made several trips up and down the Rhine. About 290 pounds of thermit were used in this case.

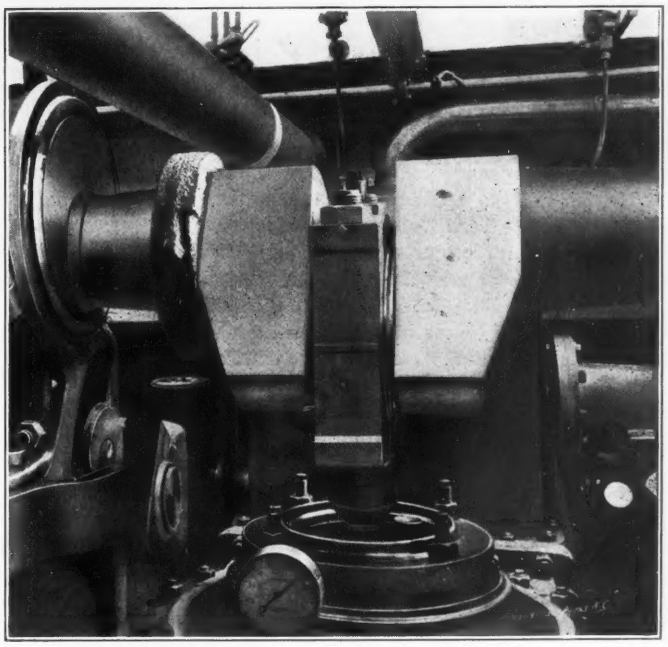

Fig. 3. Broken Crankshaft 13 3-4 inches diameter Repaired by Thermit. The Ring at the left of the Crank is the Thermit Metal.

On this side of the Atlantic Mr. Schultz has made some demonstrations of thermit possibilities, as mentioned in Mr. Perkins' article. Since welding the rail at the Worthington works, etc., he has successfully filled three bad blow-holes in the low-pressure cylinder of a large steam pump. This cylinder, having a diameter of bore of 46 inches and a stroke of about 40 inches and weighing something like five tons, revealed

three blow-holes communicating between the bore and the steam port, after the first boring chip had progressed a short distance from the end. Two of the holes were approximately circular and fully 4 inches diameter. The other hole was perhaps 1½ inches wide and 7 inches long, with nearly a right angle bend at the center. On account of the location of the casting and some other considerations, the holes were repaired successively on different days, one heat being made for each. From a superficial examination made by the writer after all the holes were repaired, the job appeared perfect so far as solidity and tightness were concerned. The molder who was in attendance, had had considerable experience in repairing broken and defective castings by "burning on." He said that it would have been impossible to have repaired this job successfully by burning because of the location of the defect. The chances were that even if a perfect union was effected, the cylinder would have cracked from unequal expansion. Thermit is so quick in its action that expansion strains are largely avoided.

The cylinder was prepared by thoroughly cleaning out the holes so that no dirt, scale, or grease should be present and was locally warmed by the application of two red-hot pieces of iron weighing perhaps 40 pounds apiece, which were allowed to remain long enough to raise the temperature around the holes to, say, 200 degrees. The warming-up process is to prevent the thermit chilling on first contact and preventing a perfect union. Over the hole was set a small cast iron flask containing a thoroughly dried open mold somewhat larger than the hole, and a gate communicating with the bottom. The mold was luted around the edge with clay so as to prevent escape of the molten metal.

The operation of setting off the thermit is simple, i. e., merely igniting the superoxide of barium powder with a match, the sheet iron cover being removed for the purpose. The cover, which is then replaced, has a hole in the center to allow the escape of the gases, and to allow the reaction to be watched, which must be done through the medium of colored glasses. After the reaction has reached the critical point as determined by the sound emitted, the tripping lever is forced upward and to one side, allowing the metal to flow into the mold. In this case as soon as the metal had chilled sufficiently, the mold was pulled off out of the way and the metal pounded down with a hammer to close up the surface and to remove some of the superfluous portion projecting above the bore.

* * *

WESTINGHOUSE ON AMERICAN METHODS.

On the night of January 9th, at Claridge's Hotel in London, George Westinghouse entertained at dinner a large company of British railway managers, financiers and scientists, among the latter being Lord Kelvin. In response to a toast proposed by Lord Kelvin (formerly Sir William Thompson), Mr. Westinghouse made a speech in which he spoke at length on American methods. He referred first to the difficulties he encountered in the early days of the airbrake when it was being introduced in England. He had much difficulty in getting the English railway managers to discard the wooden brake shoes then used and substitute cast iron shoes instead. In speaking of American methods he explained that the scarcity of labor in America had been largely responsible for the wonderful progress made in labor-saving appliances, and in this connection he said in part:

"In America, however, we have always been short-handed with regard to labor. We have been obliged to find methods whereby one man may accomplish the work of two or three men as compared with your practice here. We have had the best men from Europe: Englishmen, Germans, French, everybody—skilled men, highly trained men, as well as laboring men; we have combined their experience with our own, coupled it with our necessities, and have thus accomplished results unattainable in a country like this where you have more labor than you can well keep employed.

As an illustration of what has been accomplished by the use of electricity in a great industry, I may cite the Homestead Mills of the Carnegie Company. Mr. Schwab, whose name is well known to you, is a genius in his way, particularly in the management of men; he is a master in organizing and directing men. Mr. Carnegie believed in him, and if Mr. Schwab made a suggestion in regard to the use of new appliances, even if it involved the tearing down of an old mill and putting up a new one, the new one was ordered. What Mr. Schwab thought should be done, was done. As a result of such progressiveness, we may see the splendid mills at Homestead where they produce with about 4,000 men three times as much steel as the Krupp works produce with 15,000 men. The results are simply wonderful. You can start there to-day, in a building containing steel-melting furnaces, and you will there see three men mounted on a car with the charging apparatus which is moved and operated by electricity. With a few movements of this ingenious contrivance three men charge twenty furnaces, which, prior to the use of electricity, would have required the labor of over 200 men.

"You may go into the yard of the Homestead Mills where they pile the metal in stock. This yard is covered by a system of overhead cranes, and the result is that not only here, but in the mill, and in every other place, you may see great weights lifted and many undertakings going on without a single man exerting himself a bit—working not half as hard as I am working now. (Laughter).

"I took some English friends to Homestead. Mr. Schwab, after guiding us through several departments, said: 'I will now show you where we turn out 750 tons of plate girders per day.' The mill was in the shape of an 'L.' We went into the short end of the 'L' where the furnaces were fed by natural gas, of course requiring no stokers. The end at which we entered had a rather low roof, and there was in sight a contrivance like a battering ram in front of the furnaces; two workmen were sitting down eating their dinners near by; no one else was present. I thought: 'Mr. Schwab has made a mistake; he has asked us to see a mill that is not in operation.' But we went through the mill, which was about 200 feet long; and suddenly we heard a rattle and then saw a truck approaching, loaded with a big ingot. No one touched the truck or the ingot. The load came to a platform, the crane overhead dropped a pair of tongs and quickly put the ingot on the roller table, and as it moved along to the great rolls, it was automatically kept in place. The adjusting screws of the rolls were turned by little electric motors, and not a man in that house did a bit of work. It was just as easy as what you are doing now—looking on! (Laughter). We went back to the furnaces. There was a fifteen-year-old boy seated in a little place called the 'pulpit.' He was able, merely by the movement of levers, to open at will any of the furnace doors and move the car along. And we saw this car come in front of a furnace and the charging machine approach, and take out of the open furnace a hot ingot which was dropped on the car and moved off to its work. There was this boy doing absolutely no hard work, and his mill was turning out 750 tons of steel plate each day. My English friends said: 'England has no chance in competition with such methods.'

"Now all this sort of thing came about in America because of our necessities. We hadn't men enough to do our work. There was a premium in favor of those who could invent machines to work and thus supply the deficiency.

"At the Carnegie Mills we went to see three blast furnaces. They were making 1,800 tons of pig iron in twenty-four hours. We saw only two or three men on a truck which was moved automatically. These men were letting the ore run from chutes and mixing it in the required quantity, and when they had filled a truck, it was carried up and its contents dumped into a furnace whence it returned for another load. They were running the metal into an immense receptacle into which the metal from all three furnaces was mixed. From this place the metal was taken as required, put into a special tank, mounted on a car and taken to Homestead, two or three miles away, to be poured into the furnaces; one heating only was required."

* * *

On January 29 the Empire State Express, on the New York Central, established a new speed record. It covered the distance from Palmyra to Macedon, N. Y., 7.29 miles, in four minutes, or at the rate of 109 miles an hour.

SHOP CONSTRUCTION.—6.

HEATING THE BUILDINGS.

OSCAR E. PERRIGO.

The construction of our several buildings being now completed and all arranged with proper consideration of the existing conditions and the expected circumstances by which we shall be governed, it is necessary that we should arrange for their proper and efficient heating and lighting. In this article the first of these questions, that of heating, will be considered.

There are many systems of heating buildings, among which are: By means of exhaust steam or of live steam, in lines of pipe arranged overhead or along the walls; by coils or radiators; by hot water utilized in a similar way; by air heated by furnace arrangements or by contact with pipes

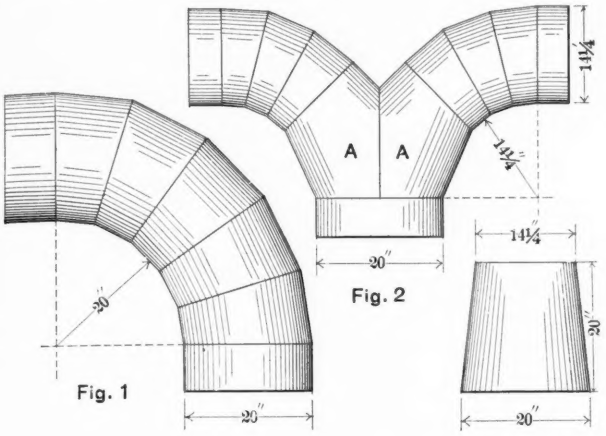

Fig. 1 Fig. 2 Fig. 3

Elbow and Divided Pipes.

through which steam flows. All these systems have their good and bad features, both as to their warming qualities and their cost, as well as the expense of operating them. The hundreds of feet of steam pipes, with their numerous fittings, furnish so many opportunities for leaks, and special arrangements must be made to keep them clear of water. The distance from the boiler to the further end of long systems frequently requires much time to force enough steam to these points to warm the rooms so that they will be endurable to workmen. The hot water system works slowly and the temperature of the surrounding air rises gradually, so that the hour for beginning work in the morning must be anticipated by such a length of time as to be a serious drawback to complete success. The hot-air furnace gives air from which much of the moisture is evaporated and which is therefore unwholesome, aside from the fine dust so often brought along with it. In all these systems heating is the only end gained, ventilation being left largely to chance.

The ideal system of warming and ventilation would seem to be that in which fresh air, warmed by steam heat, is distributed by a suitable mechanical process, as evenly as possible to every part of the building, in which this can be done in the shortest time (as in most shops the heat is not maintained during the night except at sufficient temperature to prevent freezing of water pipes, etc.), and in which cold air may be readily introduced whenever needed. This seems to be best accomplished by drawing fresh air from without the building, passing it through a heating apparatus consisting of an iron case containing a large number of steam pipes, and, by means of a fan and suitable pipes, distributing this warmed air to every part of the building by numerous outlets. The whole should be controlled by proper dampers, by which a due proportion of warm and cold air may be furnished as needed, so that proper ventilation as well as warming may always be maintained.

In the warming of such large buildings as those under consideration it is not necessary to draw cold air from the outside atmosphere to any great extent. The number of cubic feet of air contained in the building is largely in excess of that required for each person; and, moreover, cold air comes in through frequently opening large doors, while the swinging windows at the roof may be opened when necessary to permit the vitiated air to pass out, thus providing ample ventilation. Many pages might be written on this subject but space permits only a few general requirements which are practically indispensable, and may be summed up as follows:

The heating apparatus should be located near the center of the building so as to distribute the warm air to all points with the least amount of piping.

Openings should be so arranged as to be not over 30 feet apart, and to open toward the outer walls of the building. They should not be less than 8 feet above the floor, nor less than 5 inches diameter, and usually incline downward at an angle of about 10 degrees. The aggregate area of openings should exceed the area of the main pipe at the fan by about 25 per cent. About 6 square inches area of openings should be allowed to every thousand cubic feet of space contained in the building—or room, where the building is so divided. The velocity of air should not be less than 1,500 feet per minute, and a sufficient quantity should be supplied to change the air every 15 to 20 minutes.

The pipes are preferably circular, as less material is required to make them of this form; furthermore, the circular pipes are stronger, and there is less friction of air in passing through them. For instance, a circular pipe 5.65 inches in diameter will have an area of 25 square inches and its circumference will be 17.88 inches. A square pipe 5 inches each way will also have an area of 25 square inches but the sum of its four sides will be 20 inches. A rectangular pipe 2 x 12.5 inches will be of equal area but the sum of its sides will be 29 inches, or about 1.6 times greater than the circular pipe.

Nevertheless it often happens that square or rectangular pipes are necessary, on account of lack of space. When such is the case this area of cross-section must be increased accordingly, so as to avoid undue friction. Galvanized iron is the most desirable material for these pipes and is almost universally used where pipes separate from the building construction are employed. In factory buildings having several floors, proper flues and air ducts are arranged in the walls, and in the basement, where the heating apparatus is usually located.

In constructing pipes several important rules must be observed. In making a change of direction of 90 degrees the elbows should be made of not less than five pieces, and the radius of the inside of the bend should not be less than the diameter of the pipe, as shown in Fig. 1.

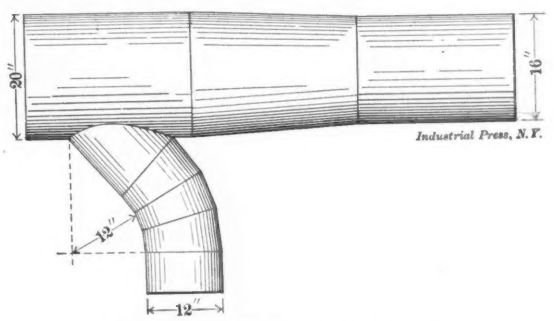

Fig. 4. Branch leading from Main Pipe.

Where a main pipe is divided, the construction should be as shown in Fig. 2, the pieces *A A* being the frustum of a cone whose diameter at the base and whose height are equal to the diameter of the main pipe, and whose smaller end is equal to the diameter of the branch pipe, as shown in Fig. 3. This pipe is then cut to the proper form to fit its counterpart, as shown in Fig. 2.

Where branches are taken off from a main or leading pipe they should be so arranged as to leave the larger pipe at an angle of not over 45 degrees, and the inside radius should be not less than their diameter, as shown in Fig. 4. The contraction of the leading pipe, due to the taking off of this branch should be made by the next sheet, the sheets being usually 30 inches wide. This reduction of area should not be

quite as much as the area of the branch pipe. The further the air travels from the fan, the less force it has, and this should be compensated for, as far as may be, by slight allowances in area as the various branches are taken off, bearing in mind that this allowance should finally lead up to 25 per cent. excess of outlet areas over the area of the main pipe at the fan.

closely to the pipes as may be, in order that all air which is drawn through may come into close contact with the heating surfaces of the pipes.

It is customary to allow one foot of 1-inch pipe, or its equivalent, to each 100 to 150 cubic feet of contents of the building to be heated, when all the air is taken from out-of-doors. In the case under consideration with one-half or

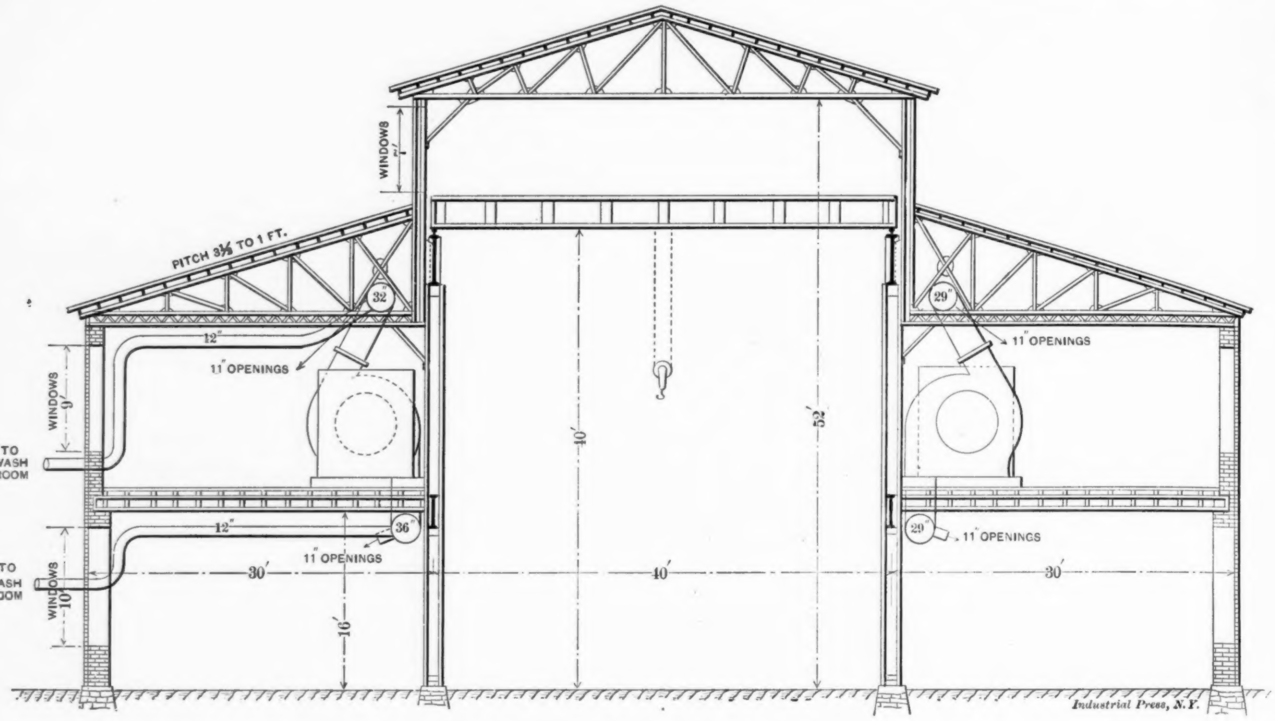

Fig. 5. Cross Section through Machine Shop.

In offices and comparatively small rooms the outlets are usually in the form of rectangular registers placed in the side walls near the ceiling. The area of these should be from two to three times the area of the pipe leading to them.

Fig. 7 shows the plan of the arrangement of the heating system of the machine shop and Fig. 5 a cross-section of the same, giving the diameters of the pipes at various distances from the heaters; and the number, direction, diameter and location of the openings, not only for the machine shop proper but for the carpenter shop, wash rooms, etc.

The heating apparatus consists of a rectangular iron case containing a large number of steam pipes of practically U-shaped form, inverted and connected to a cast-iron base in

more of the air from within the building the higher figure would probably be ample. At the end opposite the fan are located dampers for regulating the amount of air supply. One of these may be connected with a cold-air duct from out-of-doors, where necessary.

Referring to Figs. 5 and 7 the location of the apparatus is seen to be in the gallery floor, near the center of the building. The fan has two discharge openings, one downward for warming the side wings of the first floor, and one at an upward angle for the same service on the gallery floor. The returning currents of air flow into the central portion of the building and warm that portion in their upward course.

Two sets of apparatus are used, for the reason that the

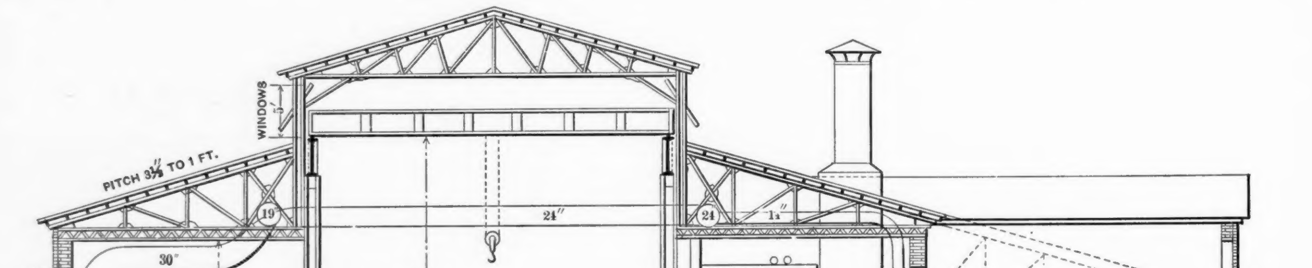

Fig. 6. Cross Section through Foundry, Cupola Platforms, Etc.

such a manner that one leg of the pipe connects with the space through which the steam is admitted and the other leg connects with the space from which the drip is taken. These pipes should be located as close to each other as practicable, the rows of pipes being set "staggering" so as to break up the currents of air; and the casing which surrounds them and connects with the inlet of the fan should also be formed as

traveling crane over the central portion of the shop prevents convenient connections between the two sides; and further, that the space to be heated is so large that the questions of convenience and economy are best met by this arrangement. The apparatus on the side nearest the power house will require a fan with a wheel, say 100 inches diameter by 52 inches wide, and running at about 185 revolutions per minute.

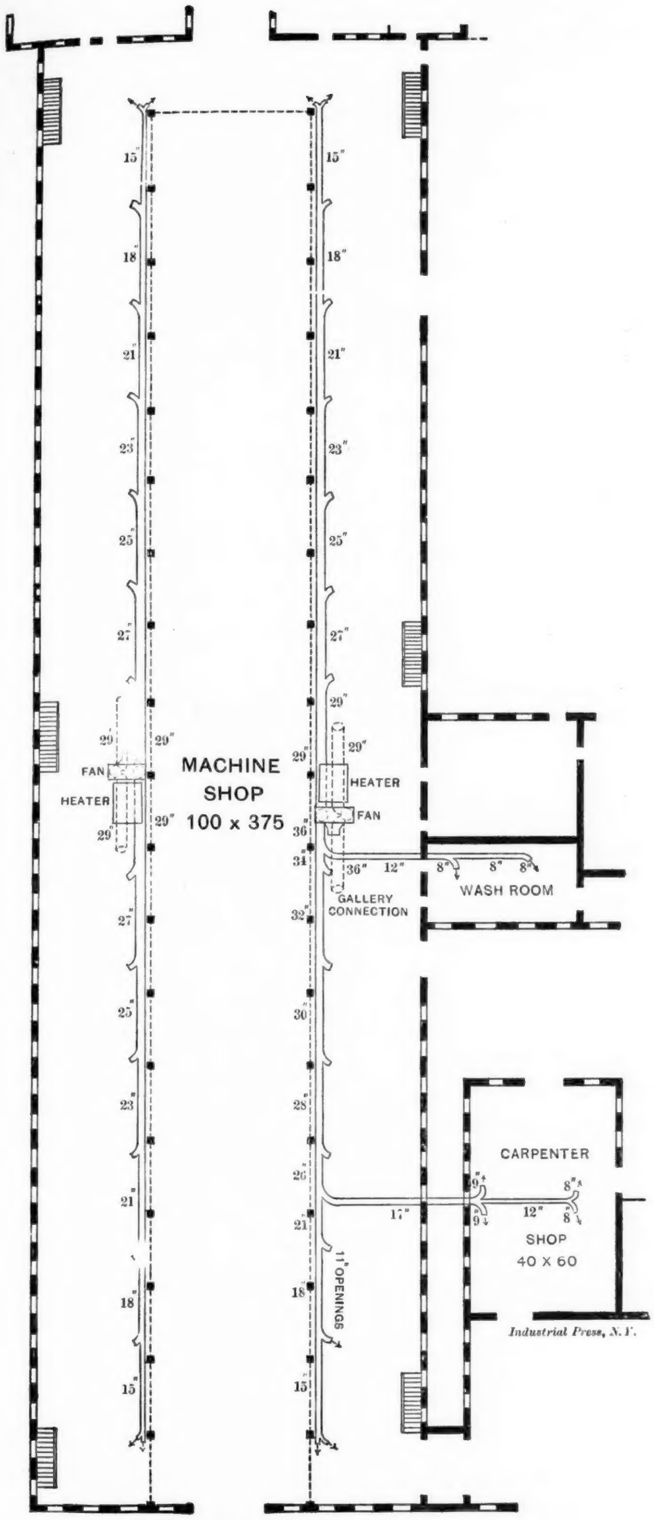

Fig. 7. Heating System for Machine Shop.

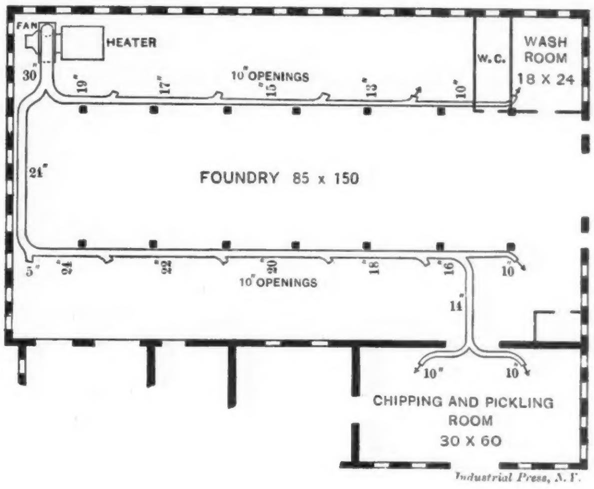

Fig. 8. Heating System for Foundry.

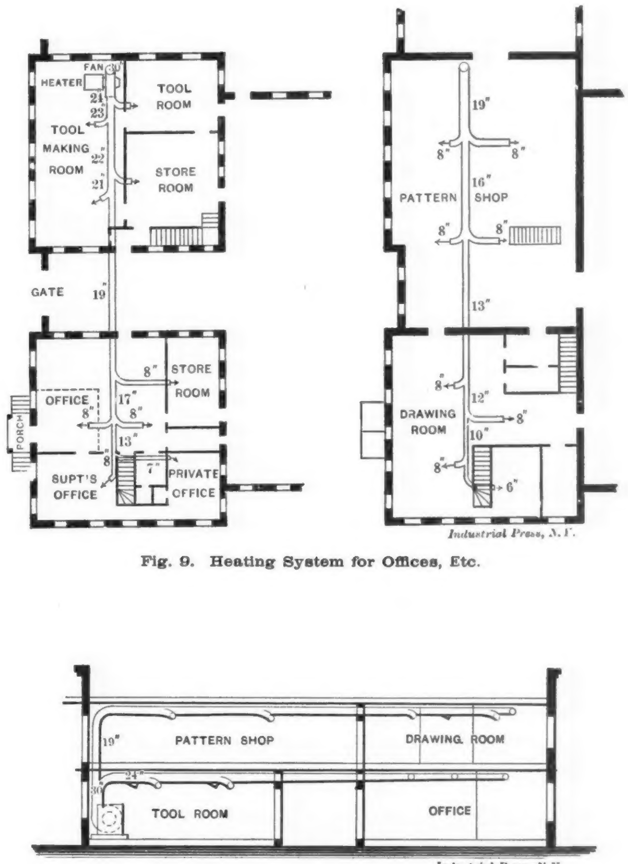

Fig. 9. Heating System for Offices, Etc.

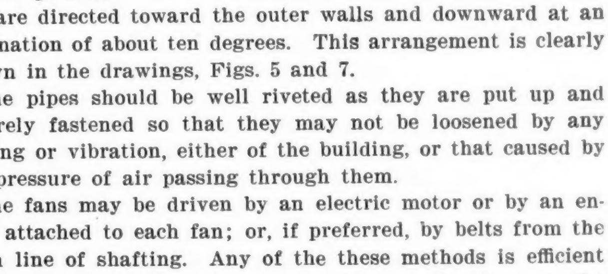

Fig. 8. Longitudinal Section through Offices, Etc.

This will supply from its downward opening the pipes for the main floor, including that leading to the carpenter shop and to the wash room on the first floor; and from its upward opening it supplies the pipes from the gallery floor, including one for the wash room on the second floor. The apparatus on the opposite side of the shop should have a fan with a wheel, say 90 inches diameter by 48 inches wide, running at about 205 revolutions per minute. The pipe connections are similar to the first apparatus, except that there are no long branch pipes to be provided for. Hence, while a 36-inch pipe is necessary for the side toward the power house, in order to warm the carpenter shop and the wash rooms, one of 29 inches diameter will be quite sufficient for the opposite side. It should be said that the dimensions given on the drawings are from actual calculations, taking into consideration all the circumstances of the form and dimensions of the buildings, and they will probably be found correct in practice as in theory.

The openings for the discharge of warm air into the building are directed toward the outer walls and downward at an inclination of about ten degrees. This arrangement is clearly shown in the drawings, Figs. 5 and 7.

The pipes should be well riveted as they are put up and securely fastened so that they may not be loosened by any jarring or vibration, either of the building, or that caused by the pressure of air passing through them.

The fans may be driven by an electric motor or by an engine attached to each fan; or, if preferred, by belts from the main line of shafting. Any of the these methods is efficient and has its particular advantages. If an engine is used, the large fan will require it to be of about 27 horse power and that for the other fan should be of about 20 horse power.

Live steam being used for heating, the large apparatus will probably require a supply pipe of 6 inches in diameter and the smaller one of 5 inches. The apparatus should be so constructed that a section of it may be separately con-

nected for using the exhaust steam from the fan engine. In the same way the exhaust from the main engines of the works may be utilized and thus save a considerable portion of the live steam required. In arranging for heating the foundry, different conditions are met with. With the exception of the chipping and pickling room heat is required hardly more than half the time, that is, during the forenoon, and perhaps for an hour or more after the dinner hour, as the heat from the cupolas is considerable.

The general plan of the system is the same as that employed in the machine shop. The apparatus requires but little room on the floor and consists of a fan having a wheel about 78 inches in diameter and 24 inches wide, running at about 400 revolutions per minute and will require about 6 horse power to drive it.

An arrangement of pipes can, of course, be made whereby the chipping and pickling room could be warmed independently of the foundry proper, but it would probably not be necessary. Figs. 6 and 8 show the arrangement of the foundry system of heating, with diameters of the pipes and openings. It will be preferable to run this fan by an electric motor or a small engine and since these fan blowers for heating purposes are now made with simple and compact engines attached to them, which require very little attention, aside from starting, stopping and oiling up, they are very convenient in such situations. It is always important to have the heater as near the space to be warmed as possible.

The office building, including the pattern shop, drawing room and tool department, is heated by an apparatus located in the tool room and forming a separate system. Fig. 9 gives plans of the first and second floors and Fig. 10 a longitudinal section through the building. A heating apparatus of the same size and capacity as that used in the foundry is employed. It may be driven by a separate engine, or a motor, or belted from the shaft which drives the machines in the tool room. This latter plan is probably the best, since the power is convenient, and the first cost may be lessened without sacrificing any desirable feature in another direction.

The system of piping is clearly shown in the illustration and needs little explanation. The main pipe passing through over the driveway must be amply protected, preferably by being encased in a wooden box several inches larger than itself, the space being filled with sawdust or similar material; and this again is covered by another box large enough to leave an air space of about 3 inches between the two, on all sides.

For the office rooms the pipes may be of rectangular form, concealed by suitable architectural finish of the ceiling, in which lateral openings for registers may be made. Or, proper air ducts may be formed in the side walls and the registers placed at suitable intervals. Or, again, the pipes may be carried around inside the walls, close to the ceilings, and registers located in the same manner. There may be for this system the double-duct arrangement. That is, two sets of pipes or ducts, one carrying cold and one warm air, the registers being so arranged that they will furnish one or the other, or a mixture of both, by means of what is technically known as a "mixing damper."

In offices and rooms of moderate size which are heated by warm air being forced into them near the ceiling, it is usual to provide means of escape for the air as it cools and descends to the floor, through grated openings placed two or three feet from the floor, and connected with flues or ducts leading to the roof. But in offices where doors are frequently opened this does not seem to be necessary, the matter of ventilation being of small consequence compared to that of heating.

The forge shop and various other buildings require no special arrangements for heating. The water closet rooms may be warmed sufficiently by providing grated openings in the wall dividing them from the boiler room. They should be near the ceiling, on each floor.

The question of proper temperature of shops where men are at active work should be considered as quite different from providing for heating a factory where the work it usually much lighter, the number of employees per hundred feet of floor space much greater, and frequently a large proportion of them females. In a machine shop devoted to a medium class of work, a temperature of about 60 degrees will be found generally comfortable to the majority of the men. We have known of shops where the temperature seldom went above 50 degrees in cold weather, and there was no complaint. The former figure will, however, be more satisfactory.

The temperature in the store room, tool room and pattern shop will need to be about 65 degrees and in the drawing room and offices, between this and 70 degrees. Unless the ventilation is very carefully attended to, there is more danger in having these latter rooms too warm than not warm enough, and any system of heating which does not recognize the importance of good and thorough ventilation is radically wrong in both theory and practice.

* * *

THE MANUFACTURE OF METAL-WORKING MACHINERY.

Census Bulletin No. 247 contains some interesting statistical matter, by Edward H. Sanborn, on the manufacture of metal-working machinery. He says the appearance of Ohio as the leading state in the manufacture of metal-working machinery points to one of the interesting phases of the development of this industry during the past ten years. Within this decade there has been a marked tendency toward specialization, particularly among the new establishments that have started business in recent years. Most of the older manufacturers of machine tools, whose business runs back for twenty or thirty years, produce a variety of machines, in some cases embracing nearly everything required for the equipment of a new shop. In late years, however, manufacturers starting in this branch of industry have very generally limited their operations to the production of a single type of machine, or at the most to one class embracing tools of similar types. For example, there are large establishments in which nothing is manufactured but engine lathes; other works are devoted exclusively to planers, while in others, milling machines are the specialty.

This tendency has prevailed in Cincinnati, perhaps, more than in any other city, and has been one of the characteristic features of the rapid expansion of the machine-tool industry in that city during the past ten years. During the census year there were in Cincinnati 30 establishments devoted to the manufacture of metal-working machinery, almost exclusively of the classes generally designated as machine tools, and their aggregate product amounted to $3,375,436. In seven shops engine lathes only were made, two were devoted exclusively to planers, two made milling machines only, drilling machines formed the sole product of five establishments, and in three shops shapers only were made. Several other manufacturers made two or more of these classes of tools, but for the most part the industry was very strikingly specialized. Cincinnati manufacturers made during the census year 3,924 engine lathes, out of a total of 12,089 for the entire country, or almost exactly one-third of the whole number. Out of 3,076 slotters and shapers made in the United States, 1,019, or nearly one-third, were made in Cincinnati. There were also made in the same city 816 milling machines and 1,622 drilling and boring machines.

Philadelphia is one of the largest of machinery centers; eleven establishments reported an aggregate product of metal-working machinery valued at $3,095,574. These products include a wide range of tools with less of the specialization than is characteristic of Cincinnati and other localities where the industry is of more recent growth.

Providence, R. I., ranks third in the manufacture of metal-working machinery, the product of fourteen establishments amounting, during the census year, to $2,929,141. Here, again, the industry is diversified rather than specialized. A large amount of automatic and semi-automatic machinery, such as screw machines, turret lathes, and gear cutters, and also milling machines of various types, are made in Providence, and these might be said to be the chief characteristic of the industry.

Hartford, Conn., stands next to Providence, and shows about the same features in the machine tool trade, with a

wide range of products, among which automatic and semi-automatic machines might be mentioned as most significant. During the census year eleven establishments in Hartford reported the production of metal-working machinery to the value of $2,796,935.

Worcester, Mass., is another important center for the manufacture of machine tools, with much of the same specialization that is manifest in Cincinnati. Twenty-four establishments reported for the census year products aggregating $2,009,357 in value. Engine lathes are one of the specialties in Worcester, and of these 2,667 were made during the census year. These, with the 3,924 made in Cincinnati, embrace more than one-half of the entire number of engine lathes made during the census year. Drilling machines of various types, particularly small sizes, are another important item in the Worcester products, 4,552 of these having been made during the census year.

While New York and Chicago are large distributing centers for machinery of every description, they do not figure prominently in the manufacture of metal-working machinery. The five large centers of the metal-working machinery industry which have been mentioned represent about one-third of the entire output of this class of machinery. The balance of the product comes from many cities, and also from a considerable number of small towns where there is a single establishment, usually making only one type or class of machines.

* * *

THE HISTORY OF ELECTRIC RAILROADING.

In a contribution to the *Technology Quarterly* upon Long-Distance Railroading, Prof. Louis Duncan gives an historical sketch of the early development of electric railroads, from which the following is taken:

Prior to January, 1888, although experimental roads had been built and were in operation in England, Germany, and the United States, yet they were not on a commercial basis, and did not offer any advantages over the then existing traction methods. At that time a road was opened in Richmond, by the Sprague Electric Railway & Motor Company, which in all essential particulars embodied the methods now used.

Mr. Frank J. Sprague graduated from the Naval Academy in 1878. While there he paid especial attention to electricity. I remember him distinctly, as captain of my gun crew at the school. For not reporting me as often as he might, he earned an esteem which twenty-four years of close association has failed to weaken. After graduation, Mr. Sprague spent six or seven years in the service. He was ordered to special duty at the Paris Exposition of 1881, and had a tour of duty at the Torpedo School at Newport. He resigned in 1885, and with Mr. E. H. Johnson, then President of the Edison Company, formed the Sprague Electric Railway & Motor Company, the object being to develop the application of motors, more especially for traction work. An experimental car was equipped and operated on a small spur of the elevated road. In the latter part of 1886, a contract was hastily closed for the equipment of the Richmond roads, and preliminary work was begun at once; but when the actual condition of affairs was investigated, it was found to be a much more difficult problem than was at first supposed.

The railroad company had stated that the maximum grade was from 6 to 7 per cent.; in reality, there were grades as high as 10½ per cent. The tracks were badly laid in streets that were unpaved and muddy, and there were a great many curves of a very short radius. However, the work was pushed forward, and the road was formally opened in January, 1888. As I have said, all the important features of modern electric cars were contained at one time or another in this first road. Series motors were used, with a voltage of approximately 500 volts at the motor terminals. A successful under-running trolley was developed, a series-parallel control was at first used, and then for reasons which at the time were good, was discarded. A single reduction gearing was at first employed, but afterwards changed to double reduction gearing. The only important feature that did not appear at one time or another in these motors was the use of the carbon brush, which is essential to the successful operation of continuous current railroad motors; this was experimented on, but was discarded, because of the indifferent quality of the carbon used.

On the day that the road was opened, there had been a heavy frost, and mud from the streets had accumulated on the tracks and frozen, the consequence being that there was no ground circuit at times. When the current was made by getting out and pushing the cars until they struck a clean rail, the inexperienced motorman as a rule had the controllers full on, and a number of motors were burned out. The brushes consisted of pieces of brass, set very much as the carbon brushes are now set; the average life of the commutator was not more than two weeks. On the first day twenty equipments were burned out. For some months the operation of the Richmond road was attended with great difficulties. The motors were not heavy enough for the work; the brushes gave an immense amount of trouble, and the roadbed itself was not fit for heavy traffic. These difficulties were gradually eliminated, and the new roads contracted for, took advantage of the experience gained.

The development from the early Richmond experience has been in the direction of making heavier and better motors, of using carbon brushes, and a series-parallel control. The essential parts of the system are, however, adhered to.

As the economy and capacity of electric equipments increased, the city roads were pushed further into the suburbs, and finally roads were built from cities to outlying towns and between cities. This movement is now probably at its maximum; a great number of interurban and suburban roads have been built and more are under construction. The interurban railroad system is simply an extension of the city tramways. The same system is used with the few modifications necessary for the much heavier cars and the much higher speeds required outside the limits of towns.

On some of the interurban roads very handsome and heavy cars are used, fitted out very much as steam cars are, and approximately of the same size, with speeds up to as much as 60 miles per hour. In fact one road is building special cars which will attain a maximum speed of 75 miles an hour, and make a schedule speed of 60 miles an hour.

When electric roads operated within a short radius, it was the custom to have a central station where the voltage was approximately that intended for use on the cars, and to distribute directly from feed wires connected at the station and to the trolley wire. When the distances became greater, a number of stations employed "boosters" for the outlying districts, the voltage being raised at the station to such an amount that the loss of potential in the feeders would be neutralized, the voltage in the outlying districts being the same as the voltage in the station. When the radius became still greater, as in the case of interurban roads, neither of these systems was applicable, and it is the custom now to distribute, when the distances are considerable, by a high potential alternating current, which, at certain points along the line, is reduced in voltage and changed to continuous current by means of rotary converters. This continuous current has a voltage of from 500 to 600 volts, and the operation from such a sub-station is similar to the operation from an ordinary central station. The advantage of this system is that it allows a very considerable length of line to be operated from a single station, thus giving economy in the generation of the power, while it does not interfere with the direct current system of operation on the cars. The disadvantages are in the cost, the losses, and the attendance in the sub-station. If the service is frequent, the average load on the sub-stations will be fairly constant, but where the service is infrequent, then the load factor of these stations is very low. This has in a great many cases been remedied by putting storage batteries in the sub-stations and running the rotary converters at a constant load, the fluctuations being taken up by the storage battery.

* * *

With the development of wireless telegraphy, it is predicted that daily newspapers will become as common on ocean liners as in our streets and that a man in need of an ocean voyage and rest from the affairs of the world will have to retire to a "tramp" steamer.

Entered at the Post-Office in New York City as Second-class Mail Matter.

MACHINERY

DESIGN—CONSTRUCTION—OPERATION.

PUBLISHED MONTHLY BY

THE INDUSTRIAL PRESS,

66 WEST BROADWAY, NEW YORK CITY.

CHICAGO—1462 MONADNOCK BLOCK. BOSTON—620 ATLANTIC AVE.
PHILADELPHIA—MACHINERY FLOOR, THE BOURSE.

LESTER G. FRENCH, Editor.
FRED E. ROGERS and GEO. H. HALL, Associate Editors.

The receipt of a subscription is acknowledged by sending the current issue. Remittances should be made to THE INDUSTRIAL PRESS, and not to the Editors. Money enclosed in letters is at the risk of the sender. Changes of address must reach us by the 15th to take effect on the following month; give old address as well as new. Domestic trade is supplied by the American News Company or its branches.

We solicit communications from practical men on subjects pertaining to machinery, for which the necessary illustrations will be made at our expense. All copy must reach us by the 5th of the month preceding publication.

MARCH, 1903.

NET CIRCULATION FOR FEBRUARY, 1903,—28,987 COPIES.

MACHINERY is issued in three editions—the Engineering Edition, printed on coated paper throughout, each volume comprising 650 reading pages and forty-eight 6x9 data sheets—price $2.00 a year; the Shop Edition, printed on super-calendered paper, comprising 430 reading pages, devoted to practical shop matter—price $1.00; and the Foreign Edition, which comprises the same matter as the Engineering but is printed on thin paper for transmission abroad—price $3.00 a year.

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THERMIT AND ITS POSSIBILITIES.

Within the past two years we have published two or three brief accounts regarding thermit and the wonders that have been accomplished by its use in Europe. On another page of this issue Mr. Perkins gives an extended account of thermit, and illustrates a recent demonstration made at the Worthington works in South Brooklyn. This article is supplemented by accounts of recent marine repairs made abroad, and one regarding the repair of a large defective steam pump cylinder at the Worthington works, which was made in the presence of an editorial representative. In view of the extraordinary work that is done by this strange compound, we have thought fit to give it considerable space and attention, believing the subject to be one of great general interest.

Thermit is the result of the investigations carried on principally by Hans Goldschmidt, of the well-known chemical firm, Th. Goldschmidt, Essen-Ruhr, Germany, in the interests of the Krupps, who were concerned in obtaining carbon-free chromium necessary in certain steel manufacture. It was discovered that finely-divided aluminum has the property of abstracting oxygen from some oxides including iron, chromium, and manganese oxides. All that is required when the aluminum and the oxide of iron and aluminum have been mixed in certain proportions, is that a small portion be first raised to a temperature somewhat less than that of melted steel. This is done in practice with a special powder that can be ignited with an ordinary flame. The reaction that follows is almost instantaneous. The whole is at once converted into a seething, boiling mass of pure molten iron, or more properly steel, and alumina slag, the temperature of the mass being something like 5,400 degrees Fahrenheit. So hot is it that ordinary graphite crucibles are broken down and made useless, a special crucible with highly refractory lining being necessary.

From what the writer has seen of actual work done, it appears that welds practically perfect can be made in wrought iron, cast iron and steel whether in thin sections or in large masses. One of the first uses to which thermit will probably be put on an extensive scale in this country, and the one that has attracted the most attention commercially in Europe, is the welding together of street car rails. By this process it is possible to make a perfect electrical "bond," and also make a joint that is somewhat stronger than the remainder of the rail. Rail welding, as now conducted in this country, requires the use of expensive and cumbersome electrical appliances. The process by which a mass of cast iron is poured around the joint to take the place of the ordinary fishplate and bolts requires a portable cupola and power. The thermit process is simplicity itself, and as many gangs as desired can be welding rails, without making a heavy expenditure necessary.

The alumina slag produced by the reaction simultaneously with the thermit metal, is a somewhat valuable by-product, being chemically the same as corundum—in fact, it is corundum. The slag is crushed and used the same as natural corundum for the manufacture of grinding wheels.

* * *

TRANSPORTATION IN NEW YORK.

The great problem that has confronted New York City for a number of years, and one that still plagues it, is providing ways and means for transporting its vast and rapidly growing population from their homes to places of business in the morning, and back again at night. These periods of transportation activity, are known as the "rush hours," and anyone not familiar with the conditions that then exist on the street cars, elevated railroad trains and the ferries, can scarcely conceive what they are. The elevated trains are usually crowded to the last degree, although the trains are run very closely together, the headway being from one to two or three minutes. This system, the Manhattan Elevated Railroad, has four lines running north and south known as the Second, Third, Sixth, and Ninth Avenue lines. During the Dewey celebration in 1898, it carried 805,000 passengers on the first day and 836,000 passengers on the second day; yet this record, which was made on the occasion of a great national event, was far eclipsed December 22, 1902, when 931,000 passengers were carried. At this time nothing of greater importance than the activity of shoppers just before Christmas, was going on. While it is by no means a fair comparison it gives some indication of the great increase of population within the past four years.

It is predicted, and with good grounds, that the Rapid Transit Subway that is being pushed so as to be completed at least a year before its specified date, will relieve the present condition very little. The population is increasing by such leaps and bounds that by the time the Subway is in running order, the conditions will be practically the same as at the present time. The great need is for tunnels and more bridges that will allow of more and quicker outlets to Long Island and New Jersey. While the suburban population is already great, there is opportunity for a far greater one within a radius of ten miles, if adequate transportation facilities were provided.

Bearing on this subject the statistics of New York State Railroad Commission are of interest. They show that during the fiscal year ending June 30, 1902 the surface and elevated roads of New York City carried 924,754,211 passengers paying fares. Of this number 625,547,434 were carried in Manhattan and Bronx and 299,206,777 in Brooklyn. These figures show that more than 2,500,000 passengers are carried daily on the different street and elevated roads of Greater New York. These roads have 330 miles of tracks within the city limits.

* * *

NOTES AND COMMENT.

The system of heating and ventilation described by Mr. Perrigo in his article on shop construction this month is that of the B. F. Sturtevant Company, Boston, Mass. Mr. Perrigo writes us that the system was developed from a very small beginning by Mr. Sturtevant himself, who began experiments about 1869. At that time Mr. Perrigo was a draftsman in the employ of Mr. Sturtevant and made the drawings for the first heater, composed of an outer case filled with pipes for heating air by the use of steam. The first experiment was

with a drum, about 12 inches in diameter and 20 inches in length. The first plants were not for heating large buildings, but for dry-rooms for lumber.

The success attending this modest beginning encouraged Mr. Sturtevant to broaden the scope of his plans until in a few years the largest and most elaborate buildings were thoroughly warmed and ventilated, and probably better than they had ever been heated before.

Prof. Dewar says that liquid hydrogen is a colorless, transparent body having a surface tension only 1-35 that of water. It does not conduct electricity and is thought to be slightly diamagnetic, that is, it is repelled from the poles of a magnet. It is the lightest liquid known, having a density only about one-fourteenth that of water. At atmospheric pressure it boils at 422.5 degrees below zero F., and at 432.5 below zero in a partial vacuum. At this temperature the liquid soon becomes a solid, resembling frozen cream, and further exhaustion of the pressure reduces the temperature to 436 degrees below zero F., or within about 24 degrees of absolute zero. The strong condensing power of liquid hydrogen makes it a simple means of producing a high vacuum, so high indeed that the electric discharge passes through it with great difficulty.

In the automatic threading lathe made by the Automatic Machine Co., Bridgeport, Conn., a solid nut about 9 inches long is used in the carriage apron in place of the common opening nut found in engine lathes. This nut is bushed with babbitt and the thread is cut in the babbitt on one of their automatic lathes. To clear out the fins and size the nut it is, of course, necessary to run through a tap, but if a hardened tap was used for the purpose, the accuracy of the lead would very likely be destroyed, so a soft tap is used instead. The tap is made from unannealed steel and fluted in the ordinary manner, but is not hardened. The amount of metal that it has to remove is small, so the difficulty that some might anticipate from using an unhardened tap is not serious.

In this shop a form of lathe tool that is largely employed for thread-cutting, consists of a simple holder having a set-screw to hold the steel cutter, which is made of round stock. The cutter is milled to the required width with straddle mills and is relieved on the side by filing before hardening. The cutter, having a round body, may be twisted to any angle required by the pitch of the thread to be cut. This often saves considerable grinding and fussing to get the angle of the blade just right, so that it will clear on the sides.

Roller bearings have received a somewhat severe test in connection with the perfecting printing presses of *The Providence Journal*, Providence, R. I. Roller bearings have been used in Providence so successfully for jewelers' rolling mills and other heavy work that when a Hoe perfecting press was ordered for the *Journal* office, roller bearings were specified, much against the advice of the printing press factory. In printing, as in perhaps no other class of work, the cylinders which give the impression of the type upon the paper must stand up rigidly to their work without deflection or uneven motion tending to produce slurring. In fine "cut" work especially is this necessary, otherwise the beautiful results obtained in our best illustrated magazines would be impossible. It is generally assumed that the journals of the impression cylinders must be closely fitted in their bearings, and it would naturally be supposed that a solid metal-to-metal contact would be better than where rollers are placed between the two surfaces. *The Providence Journal* has recently stated, however, that the roller bearings have given perfect satisfaction. The bearings have worn smoothly and evenly and have required no attention. After operating five years, inspection showed that neither the rolls nor the surfaces of the bearings or journals had worn perceptibly. The press can be turned easily by hand, and it is estimated that there is a saving of about 4 horse power in operating it, through the reduction in friction at the bearings. The Hoe company now use roller bearings regularly on many of their machines.

NOTES OF TRAVEL.

GAS AND OIL ENGINES IN GERMANY.

Editor MACHINERY:

A very complete and most excellent display of internal combustion engines was made by the Gasmotoren-Fabrik-Deutz at the Dusseldorf Exhibition in the summer of 1902. The display was so representative of internal combustion motor practice in Germany, and so valuable, that it led to a visit to the works of the company at Deutz near Cologne. A cordial reception and free access to the entire establishment were granted. While passing through the various departments information was freely given and questions fully answered.

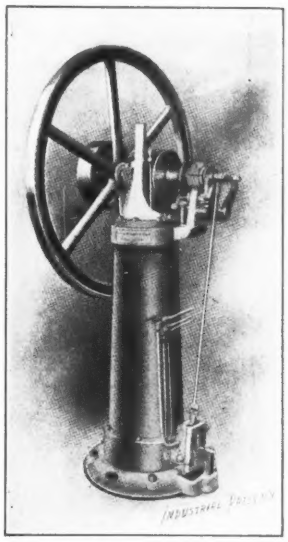


Fig. 1. The First Gas Engine. Exhibited at Paris in 1867. The Piston drives the Shaft through a Rack, Pinion and Ratchet Mechanism.

In the two places, the exhibition and the works, gas, oil and spirit engines for practically all such purposes as steam, electric and water motors are commonly applied to, were seen in operation and under construction in sizes ranging from one-half horse power to 1,200 horse power. Several types of gas generators for supplying fuel to the gas motors were also shown in operation. The generators are made in different types to meet the conditions of gas making from soft and hard coal, and from coke.

The first of all gas motors was in operation at the exhibition. It is the same that was exhibited at the Paris Exhibition in 1867, where it received the gold medal. Its capacity is one-half horse power. Although it is so well known, a brief explanation and an illustration may, nevertheless, be acceptable. The walls of the vertical cylinder form the lower part of the pedestal and frame which support the horizontal main shaft above and slightly to one side of the center line of the cylinder. There is neither crank nor connecting-rod for transmitting the motion of the piston to the main shaft. Instead of this now universally-adopted device the piston drives the main shaft through a gear rack attached to the

Fig. 2. The First Four-stroke Gas Engine. Otto Cycle, Connecting-rod and Crank.

center of the piston, after the manner of a piston rod, and engaging with a spur gear on the shaft. The gear is free to rotate in one direction on the main shaft, but drags the shaft with it in the opposite direction by means of a pawl and ratchet connection. When the piston is projected upward by the explosion of a charge of air and gas mixture the gear is rotated in its free direction on the main shaft by the piston rack. As the piston descends by its own weight and atmospheric pressure, it drives the main shaft. By this device no heavy shock is brought upon the power transmitting parts of the machine. The design is not suitable to large powers, however, and even for small capacities a large machine is required.

The first gas engine with crank and connecting rod was

also exhibited. It is spoken of by the manufacturers as the "four-stroke" engine. An explosion can occur not oftener than every fourth single stroke of the piston in accordance with the now well-known Otto cycle. The type of this engine, with modifications and improvements, is still used in the Otto gas engine.

The works of the Gasmotoren-Fabrik-Deutz have a floor space of ninety thousand square meters (about 963,000 square feet). There are about two thousand employes. Power for the machinery is furnished by gas motors suitably located about the buildings. The entire works are lighted by electric light, arc and incandescent. All the electric generators are driven by gas motors. Storage batteries are used in connection with the incandescent lamps to secure a steady illumination. All the lights were burning satisfactorily late in the evening of a winter day. There was no indication of flickering. There are two electric plants, one in the old, and the other in the new section of the buildings.

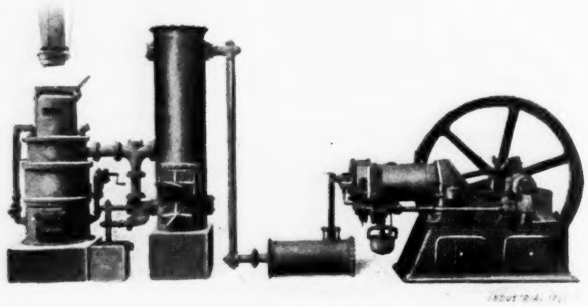


Fig. 3. Power Unit, consisting of a Suction or Inhalation Gas Generator, Washer and Engine. For Hard Coal and Coke.

One pair of electric generators was belt-driven by a two-hundred horse power engine receiving gas from a gas generating plant of the type known as the Saug-Generatorgas-Anlage (suction or inhalation gas generating plant). The necessary draft for keeping up combustion in the gas generator is caused by the suction of the engine as it takes its charge of explosive mixture. Air and steam are drawn into the hot coals at the bottom. The gas plant, together with the motor, are shown in the illustration. The fuel used when the plant was seen in operation was anthracite pea coal. The generator is adapted to both this and coke. No gas storage tank of variable capacity is used in connection with this power generating unit. The gas passes from the generator on the left in the illustration to the washer immediately adjoining it, and thence direct to the engine. The small tank between the engine and washer has enough capacity to allow, by the expansion of the gas in it, for the sudden demands of the engine for fuel. The engine, by its suction or inhalation action, draws just sufficient air and steam into the bed of hot coals in the generator to produce the amount of gas needed to meet the demands for power. Moisture from the washer may collect in the drum between the washer and engine. For the sake of cleanliness and absence of gas in the engine room, the producer and washer are placed in a room separated from the engine by a partition wall. A one-thousand horse power gas producing plant of the above type was in operation at the Dusseldorf Exhibition.

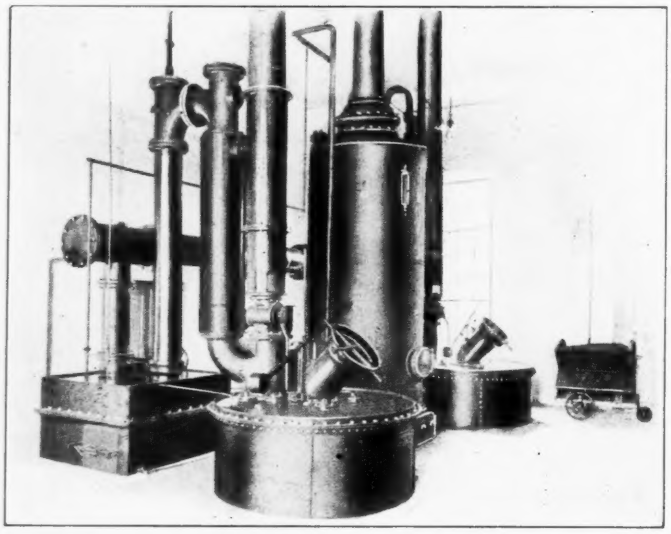


Fig. 4. Illuminating Gas Plant.

For the utilization of the soft coals of Germany another type of gas generator is built. Unlike the old retort method of gas production with a residue of coke, this generator consumes the coal completely, except such ash as remains from an ordinary fire. The arrangement of this Braunkohlen-Generatorgas-Anlage (brown or soft coal gas generator plant) is shown in the cut, Fig. 5. The generator *A* is closed during the production of gas. Steam and air are blown into it through the pipe connected to the bottom of the shell; or air alone may be forced in. The gas passes from the generator through the condenser *B*, washer *C*, condenser *D* and on into the tank *E*. The latter has a floating upper half with edges submerged in water. The coal is charged on through the hopper at the top of the generator *A*, and the ash removed from the bottom. The reservoir supplies gas to the engines when the generator is opened for charging and removing the ash, and also stores the gas during short stoppages of the engine. Although especially designed for soft coal, this generator can be used for coke and hard coal. It is said that it will operate successfully with any coal on the continent. A sixty horse power gas plant of this type was in operation at the exhibition and another at the works of the company. One of these generators will retain fire for fourteen days when out of service, and can be brought up to its working capacity in a fraction of an hour. The makers state that, with this generator, power can be delivered by a gas engine at a cost from two-thirds to one and a quarter pfennigs (one-sixth to five-sixteenths of a cent) per horse power per hour. They also point out that the cost of a horse power is much less for the gas motor than the steam engine. This producer is made in capacities ranging from fifty to one thousand horse power.

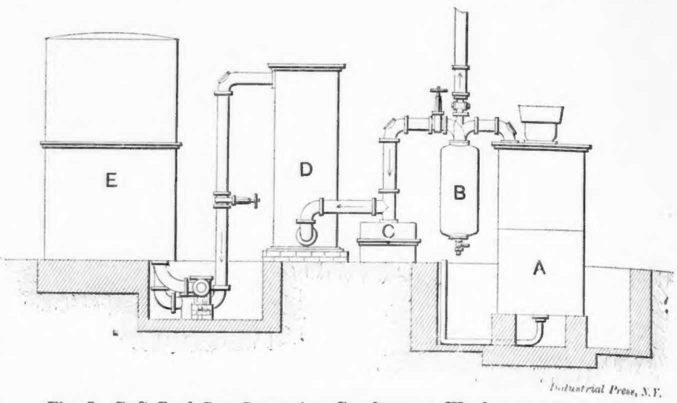


Fig. 5. Soft Coal Gas Generator, Condensers, Washer and Tank. May also be used for Hard Coal and Coke.

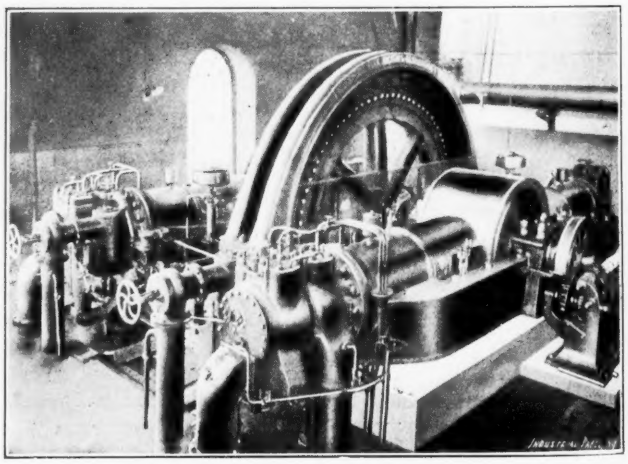


Fig. 6. Four-cylinder Blast Furnace Gas Motor of 1000 H. P.

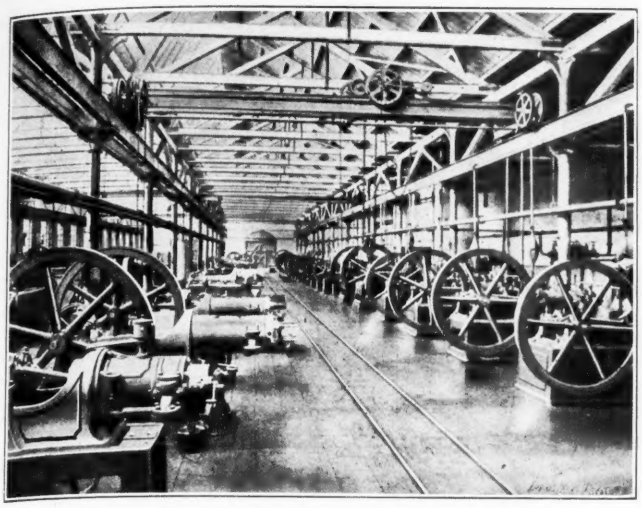


Fig. 7. Testing Room for Small Motors, Gasmotoren-Fabrik, Deutz.

Many of the engines built by the firm are suitable for blast furnace gas. Such a one of twelve hundred horse power capacity with four cylinders was exhibited. Others of one thousand horse power each were well toward completion in the works.

Gas motors forming part of direct-connected units of large

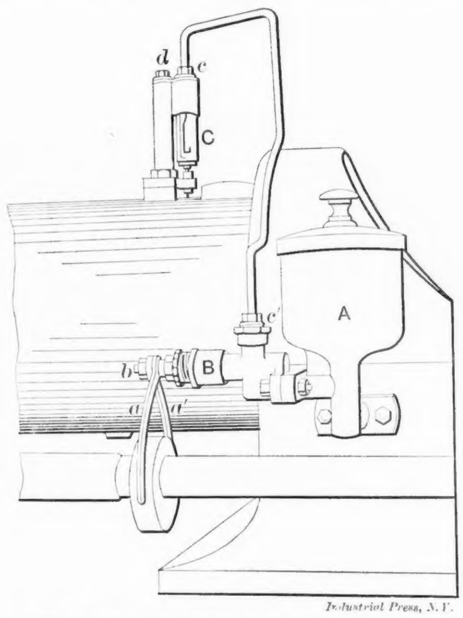


Fig. 8. Simple Lubricator, Positively Driven.

capacity are in operation in several cities in Germany and other continental countries for electric lighting and electric power purposes. Stationary electric motors and electric tram cars are among the types of machinery supplied with current. The engines are also used extensively to pump water for city supply.

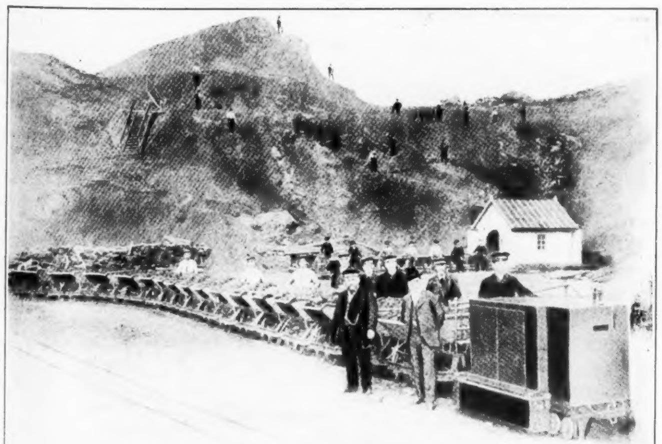


Fig. 9. Gasoline Locomotive operating Slag Cars.

Liquid burning internal engines are made in forms adapted to the propulsion of boats, winches, fire engines both automobile and horse drawn, traction engines for threshing machines and portable sawmills, traction engines for haulage purposes chiefly, and numerous other purposes. Internal combustion engines for crude petroleum are included in the output. This type has not yet been adapted to very small powers, however, on account of clogging in the very small tube used for conveying the petroleum from the pump to the engine cylinder. An industrial railway with motive power supplied by an oil-burning internal combustion engine was in operation alongside another of the same size but having a storage-cell electric locomotive. The showing of the oil locomotive was very good indeed.

All motors are tested before leaving the works. The testing rooms occupy a considerable portion of the plant. That for small motors is very completely fitted with all appliances necessary for convenience in making trials.

The cylinder lubricator, an important adjunct to the internal combustion engine, is driven by a cam on the valve-operating shaft which runs parallel to the length of the engine. There is a double-contact cam follower, resembling very closely a pair of jointed outside calipers, which straddles the cam. The quantity of oil supplied to the cylinder depends upon the amount of motion of the follower. This is regulated by a screw which adjusts the distance between the legs of the follower, just as in a pair of screw-adjusted calipers. This appliance is mentioned in detail for the reason that it

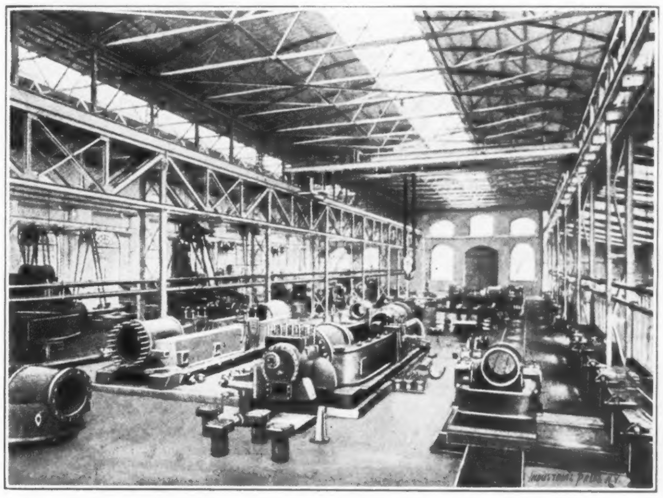


Fig. 10. Erecting Room for Large Motors, Gasmotoren-Fabrik, Deutz.

has an important feature that is lacking in the very common form of belt-driven lubricator, namely, positiveness of action. It is not uncommon to see a belt-driven lubricator stop while the engine is running. Any one familiar with the gas and oil engine knows how serious may be the result of the consequent failure of cylinder lubrication.

The company states that there are in operation more than sixty-one thousand of its motors, aggregating in round numbers, three hundred and twenty-five thousand horse power.

FORREST R. JONES.

London, England.

* * *

A writer in the *Foundry* who has had considerable experience in such matters, says that defective iron castings can be more easily repaired by "burning" with brass than with iron. Less metal is required and the results average better. As an illustration, he quotes a cylinder that was nearly machined when a hole was discovered in the barrel near one of the ports. It was located so that it could not be plugged and to burn it was considered a big risk, besides there was not room enough inside the casting to hold sufficient iron to burn it. The cylinder was repaired quite successfully by burning the hole with brass. The metal used was composed of copper 16 parts, yellow metal 6 parts, lead 3 parts, and tin 1 part. For burning iron it should be "jumping" hot. The metal is very fluid, searching, soft and easily machined, and is malleable when cold, so that it may be calked.

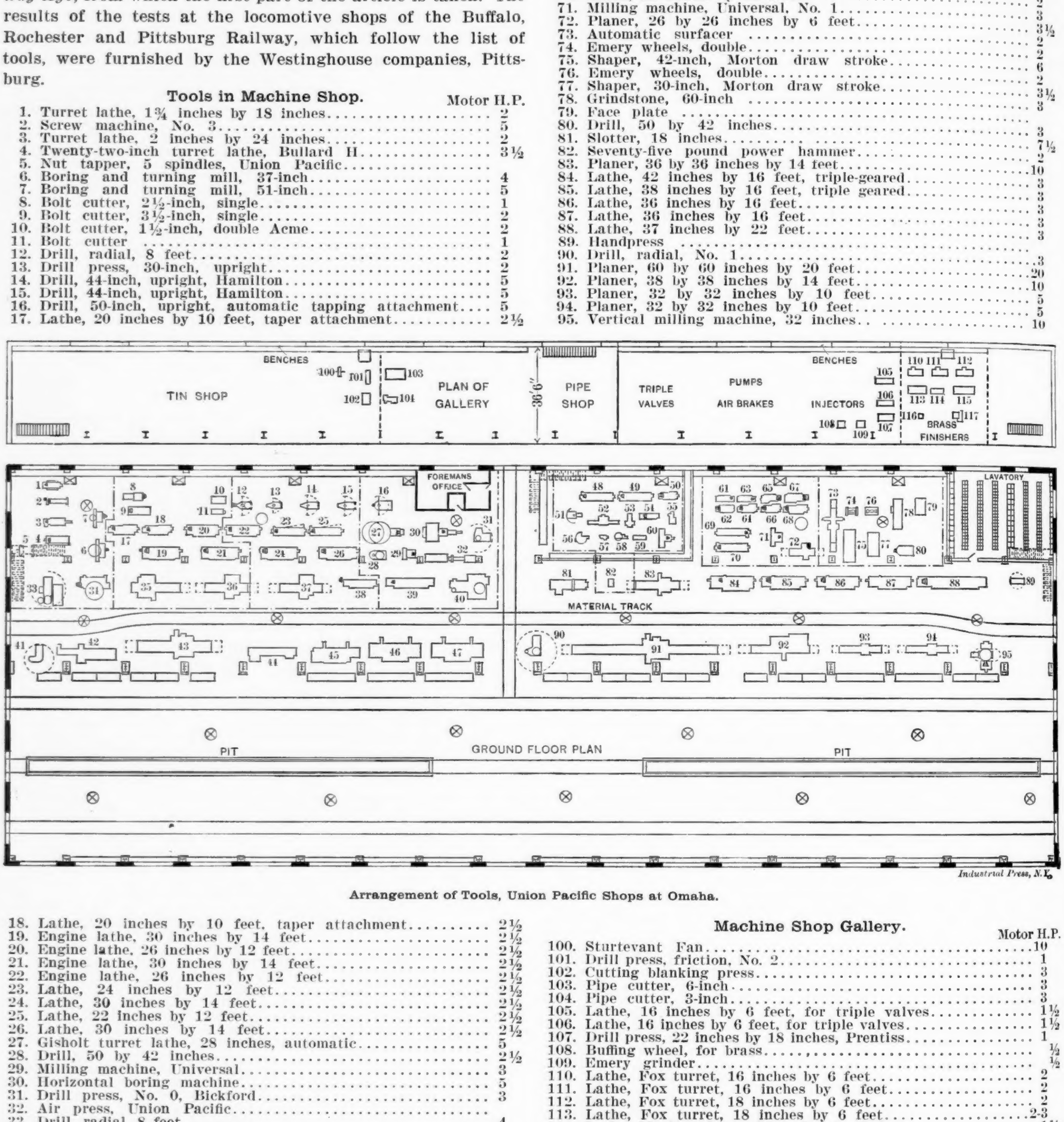
MOTOR POWER FOR MACHINE TOOLS.

DATA UPON MOTOR EQUIPMENT AND TESTS OF POWER FROM TWO RAILROAD SHOPS.

The Union Pacific Railroad is building extensive repair shops at Omaha, Nebraska, which will be equipped with modern tools and appliances throughout. The accompanying list of motors and tools, and the diagram showing the arrangement of the tools in the shop were first published in the *Railway Age*, from which the first part of the article is taken. The results of the tests at the locomotive shops of the Buffalo, Rochester and Pittsburg Railway, which follow the list of tools, were furnished by the Westinghouse companies, Pittsburg.

Tools in Machine Shop.

		Motor H.P.
1.	Turret lathe, 1¾ inches by 18 inches	2
2.	Screw machine, No. 3	5
3.	Turret lathe, 2 inches by 24 inches	2
4.	Twenty-two-inch turret lathe, Bullard H	3½
5.	Nut tapper, 5 spindles, Union Pacific	
6.	Boring and turning mill, 37-inch	4
7.	Boring and turning mill, 51-inch	5
8.	Bolt cutter, 2½-inch, single	1
9.	Bolt cutter, 3½-inch, single	2
10.	Bolt cutter, 1½-inch, double Acme	2
11.	Bolt cutter	1
12.	Drill, radial, 8 feet	2
13.	Drill press, 30-inch, upright	2
14.	Drill, 44-inch, upright, Hamilton	5
15.	Drill, 44-inch, upright, Hamilton	5
16.	Drill, 50-inch, upright, automatic tapping attachment	5
17.	Lathe, 20 inches by 10 feet, taper attachment	2½
18.	Lathe, 20 inches by 10 feet, taper attachment	2½
19.	Engine lathe, 30 inches by 14 feet	2½
20.	Engine lathe, 26 inches by 12 feet	2½
21.	Engine lathe, 30 inches by 14 feet	2½
22.	Engine lathe, 26 inches by 12 feet	2½
23.	Lathe, 24 inches by 12 feet	2½
24.	Lathe, 30 inches by 14 feet	2½
25.	Lathe, 22 inches by 12 feet	2½
26.	Lathe, 30 inches by 14 feet	2½
27.	Gisholt turret lathe, 28 inches, automatic	5
28.	Drill, 50 by 42 inches	2½
29.	Milling machine, Universal	3
30.	Horizontal boring machine	5
31.	Drill press, No. 0, Bickford	3
32.	Air press, Union Pacific	
33.	Drill, radial, 8 feet	4
34.	Boring and turning mill, 8 feet 2 inches by 7 feet	6
35.	Planer, 60 by 60 inches by 12 feet	8
36.	Planer, 36 by 36 inches by 12 feet	6
37.	Planer, 36 by 36 inches by 12 feet	6
38.	Locomotive axle lathe, No. 6	5
39.	Engine lathe, 26 inches by 16 feet	3
40.	Slotter, 24 inches	8
41.	Drill, radial, 5 feet, Universal	3
42.	Three-spindle cylinder borer	10
43.	Planer, 72 by 84 inches by 16 feet	10-25
44.	Hydraulic driving wheel press, 90 inches, 300 tons	10
45.	Driving wheel lathe, 80 inches	7½
46.	Driving-wheel lathe, 90 inches	15
47.	Driving-wheel lathe, 90 inches	15
48.	Lathe, 24 inches by 12 feet, taper attachment	2½
49.	Lathe, 22 inches by 12 feet	2
50.	Lathe, 16 inches by 6 feet	1-2
51.	Drill press 30 inches upright	2
52.	Universal grinder, No. 2, imp	2
53.	Shaper, 16 inches, back geared	1
54.	Brass lathe. Monitor, 15 inches by 5 feet	1½
55.	Gear cutter	4..
56.	Tool grinder, No 90	½
57.	Twist drill grinder, Yankee	½
58.	Universal grinder, No. 3	2½
59.	Emery wheels	½
60.	Milling machine, No. 13, Universal	2
61.	Lathe, 16 inches by 6 feet	1
62.	Lathe, 16 inches by 6 feet	1-2
63.	Lathe, 16 inches by 6 feet	1-2
64.	Lathe, 16 inches by 6 feet	1-2
65.	Lathe, 16 inches by 6 feet	1-2
66.	Lathe, 16 inches by 6 feet	1-2
67.	Lathe, 18 inches by 8 feet	1-2
68.	Lathe, 18 inches by 8 feet	1-2
69.	Lathe, 22 inches by 12 feet	2
70.	Lathe, 22 inches by 12 feet	2
71.	Milling machine, Universal, No. 1	3
72.	Planer, 26 by 26 inches by 6 feet	3½
73.	Automatic surfacer	2
74.	Emery wheels, double	2
75.	Shaper, 42-inch, Morton draw stroke	6
76.	Emery wheels, double	2
77.	Shaper, 30-inch, Morton draw stroke	3½
78.	Grindstone, 60-inch	3
79.	Face plate	
80.	Drill, 50 by 42 inches	3
81.	Slotter, 18 inches	7½
82.	Seventy-five pound power hammer	2
83.	Planer, 36 by 36 inches by 14 feet	10
84.	Lathe, 42 inches by 16 feet, triple-geared	3
85.	Lathe, 38 inches by 16 feet, triple geared	3
86.	Lathe, 36 inches by 16 feet	3
87.	Lathe, 36 inches by 16 feet	3
88.	Lathe, 37 inches by 22 feet	3
89.	Handpress	
90.	Drill, radial, No. 1	3
91.	Planer, 60 by 60 inches by 20 feet	20
92.	Planer, 38 by 38 inches by 14 feet	10
93.	Planer, 32 by 32 inches by 10 feet	5
94.	Planer, 32 by 32 inches by 10 feet	5
95.	Vertical milling machine, 32 inches	10



Arrangement of Tools, Union Pacific Shops at Omaha.

Machine Shop Gallery.

		Motor H.P.
100.	Sturtevant Fan	10
101.	Drill press, friction, No. 2	1
102.	Cutting blanking press	3
103.	Pipe cutter, 6-inch	3
104.	Pipe cutter, 3-inch	3
105.	Lathe, 16 inches by 6 feet, for triple valves	1½
106.	Lathe, 16 inches by 6 feet, for triple valves	1½
107.	Drill press, 22 inches by 18 inches, Prentiss	1
108.	Buffing wheel, for brass	½
109.	Emery grinder	½
110.	Lathe, Fox turret, 16 inches by 6 feet	2
111.	Lathe, Fox turret, 16 inches by 6 feet	2
112.	Lathe, Fox turret, 18 inches by 6 feet	2
113.	Lathe, Fox turret, 18 inches by 6 feet	2-3
114.	Lathe, Monitor, brass, 15 inches by 5 feet	1½
115.	Lathe, Fox turret, 18 inches by 6 feet	2-3
116.	Drill, 24 inches, upright	1
117.	Milling machine, No. 1	3

The machine and erecting shop is 150 x 400 feet. It is arranged on the longitudinal plan with three tracks on the erecting side, spaced 23 feet center to center, and the middle track has two pits 150 feet long. A fourth track is located 32 feet from the inner track, for conveying material to the heavy lathes, planers, etc. The west side of the shop is provided with a gallery running the full length and is located at a height that gives 19 feet head room beneath the floor girders and the ground floor. In the grouping of the machines the object has been to so locate them as to facilitate the passage of work through the shop and to avoid, so far as possible, the work traveling twice over the same route.

TESTS AT THE LOCOMOTIVE SHOPS OF THE BUFFALO, ROCHESTER & PITTSBURG RAILWAY.

Tests have recently been made at the locomotive shops of the Buffalo, Rochester & Pittsburg Railway for the purpose of ascertaining the amount of power used by the different machine tools when operating on regular routine work. As the tools are driven by the group system it was also possible to determine the percentage of power absorbed by the shafting and belting used in the various groups. The net power consumed by the various tools was not obtained directly, but by subtraction. All measurements were made by voltmeter and an ammeter in the motor circuit. These indicated the electrical horse power delivered to the motor, and the brake horse power delivered by the motor at any given load was then determined approximately by means of the motor efficiency curve. The amount of power consumed by the shafting and belting being known, and then the amount consumed with the tool running being taken, the first quantity was subtracted from the latter to give the amount actually consumed by the tool. This probably gave very nearly the correct results, since the energy lost in shafting and belting is very nearly constant at various loads. The tests were made while the shops were in full daily operation and it was for that reason impossible in many cases to make as direct measurements as might seem desirable.

The steam engines in the power house, and the generators and motors were installed by the Westinghouse companies. There are three separate units in the power house, one D. C. for power and lighting for the day load; one D. C. for power and lighting for the night load; and one A. C. unit for lighting the grounds and transmitting current for lighting car shops and several railway stations at a distance. The different groups of tools were driven by shunt motors which at present have rather small loads allotted to them in view of possible increases in the capacity of the shops at some future time and from the fact that experiments are now being conducted with high-cutting steels, which, if adopted, will considerably increase the demands for power.

The tests, in addition to furnishing data relating to the power required for various tools, when starting, running light, and cutting, also make possible some estimation of the merits of roller bearings for shaft hangers. The line shafts are of cold-rolled steel and are carried on Hyatt roller bearings, and a shaft 200 feet long, without belts, can be turned by hand. But in spite of the unusual efficiency of the bearings it will be noted that the power consumed by the tool is often less than that lost in transmission. Nevertheless the capacity in motors required for the group drive is two and a half times smaller than it would have been had each tool been provided with an individual motor. It is a question as to how far the low average power taken by large groups of tools in operation may be due to the flywheel effect of the shafts and pulleys.

The locomotive-erecting, boiler and machine shop consists of a middle aisle for erecting, and of two shed bays equipped with shafting for driving the machine tools. Two 50-ton, electric traveling cranes have a runway in the middle aisle. There are five lines of shafting driven by five shunt motors in the shed bays and the sections are designated as wheel section and boiler section in one bay, and lathe, tool, and flue sections in the opposite bays.

Tests were run in the different sections upon various groupings of the tools, and also upon single tools in each section, but space will be given here only to the results obtained with the single tools as it is not likely that the group tests would be of material value to any not interested in this particular plant. We include, however, the results of tests on the shafting and belting.

In the wheel section the line shaft is 200 feet long, 2½ inches in diameter, and has 26 hangers. It was inconvenient in this instance to obtain a test of the line shaft alone, but a test of the line shaft and counters indicated only 1.5 horse power.

A 42-inch wheel lathe with one tool cutting took, on starting up, 4.6 horse power, and on steady running .5 horse power.

An emery wheel took .7 horse power.

A 79-inch wheel lathe with two tools making roughing cuts on a pair of drivers took 4 horse power.

An 84-inch boring mill boring an 8-inch cylinder took 2 horse power.

A 60-inch planer cutting a cast-iron cylinder took 2 horse power, and a maximum at reversal of 8.5 horse power.

An 18-inch slotter with tools of ¾-inch face cutting steel took .3 horse power, and a maximum at reversal of 1.2 horse power.

A band saw starting up took 6.3 horse power and running light or cutting 4-inch oak 4 horse power; it seemed to make no difference whether the saw was cutting or not.

In the boiler section all the counter-belts were thrown off and the line shaft tested alone, with a result of .3 horse power. This line shaft is 170 feet long, 2½ inches in diameter and has 19 hangers. The speed of the line shaft was 158 revolutions per minute. A test of the line shaft and countershafts only, gave an average of 2 horse power.

First a group of several tools was tested; then a single tool, the No. 4 Hilles & Jones 48-inch punch and shear was thrown in, and starting up light took 6.9 horse power, settling down to .4 horse power. Shearing 5-16-inch steel plate, it required 3 horse power.

A 6-foot radial drill was then added, and at starting up light took 3.6 horse power, settling down to 1.1 horse power. A 1½-inch drill cutting in steel gave 1.5 horse power.

A set of 12-foot rolls was then added, and starting up light showed 7.3 horse power, settling down to 4.75 horse power. Rolling steel plates, ½-inch by 8-inch required 5.3 horse power.

A 1-inch stay-bolt cutter added to the above took on starting up 4.5 horse power, and cutting 12 threads per inch gave 2.1 horse power.

In the lathe section the line shaft and counters gave 4.1 horse power. A test of the line shaft with counter-belts off gave .7 horse power. The speed of the line shaft was 155 revolutions per minute. The line shaft is 180 feet long, 2½ inches in diameter, and has 22 hangers.

Besides the group tests it was found that a single 26-inch planer cutting cast-iron took 1 horse power, and at reversal 3.5 horse power.

A 16-inch shaper cutting 1-32-inch steel at 12-inch stroke took .9 horse power, with a minimum of .2 horse power and a maximum of 1.4 horse power.

A 24-inch turret lathe cutting required .3 horse power.

A 24-inch lathe boring brass took .03 horse power.

In the tool section the line shaft and counters required 2.8 horse power. The line shaft is 140 feet long, 2½ inches in diameter, and has 20 hangers. It was not convenient to obtain a test of the line shaft alone. The speed of the line shaft was 155 revolutions per minute.

A single grinder took in starting up 9.7 horse power, and grinding 1.95 horse power.

A 28-inch lathe took on starting 4.7 horse power, and cutting steel 2.5 horse power.

In the flue section a test of the line shaft with all counters gave .6 horse power. A test of the line shaft gave .035 horse power. The line shaft is 90 feet long, 2½ inches in diameter, and has 12 hangers.

A single flue welder with blowing fan attached required on starting up 7.1 horse power; running light it took 3.4 horse power.

The pipe cutter cutting 2½-inch pipe took .06 horse power.

The auto-flue cleaner, cleaning 2-inch flue, took .2 horse power.

* * *

The floating machine shop Vulcan, used by the navy department during the Spanish war, created much interest at the time of its inception. There is now a similar novelty on Lake Champlain, but in this instance in the wood-working line. A floating sawmill is in use there, which resembles its predecessor, the ark, but with modern improvements. It is a two story structure with boiler, engine and sawmill on the first floor, or lower deck, according to whether the sawmill or marine features are supposed to predominate, and the quarters for the crew on the upper deck. There was a time when a great deal of timber was cut on the shores of Lake Champlain, but now the shores are not so heavily wooded as formerly, there are many stray ends of timber, that can be profitably worked up into lumber by this floating mill.

STEAM ENGINE SPECIFICATIONS.

FORM FOR SPECIFICATIONS FOR MARINE ENGINES.

The following form for marine engine specifications was prepared by our correspondent, Mr. William Burlingham, and first appeared in "Steam Engineering" when that journal was published by THE INDUSTRIAL PRESS, the publishers of MACHINERY.. While these specifications apply specifically to a triple-expansion engine of the commercial marine class destined for a passenger boat of 16-knots speed, they are, in general, applicable to the type of engines that are in the majority in use on our coast. They will apply, however, equally well to land work with some judicious pruning of the features particularly applicable to marine conditions, such as thrust bearings, propeller wheels, etc. The materials specified are suitable for a first-class engine, but changes can, of course, be made to meet the conditions in that respect.

The usual method of supplying specifications is by blueprints, but during the past few years, the best firms have made a practice of having their specifications printed, and cheaply but serviceably bound. The latter is by far the better method. The general specifications at the end may be omitted if thought necessary and all the machine and foundry work allowed to go as the local inspector decides.

Machinery Specifications for Triple-expansion Marine Engines.

High Pressure Cylinder...........diameter..........inches.
Intermediate Cylinder.............diameter..........inches.
Low Pressure Cylinder............diameter..........inches.
Stroke ....inches.
Revolutions ....per minute.
Steam Pressure ....pounds per square inch.
For a boat of following dimensions:
Length on L. W. L...........................
Length over all...............................
Beam, Moulded ....
Depth, Moulded ....
Draft, Mean ....
Displacement ....
Speed..........at............tons displacement.

General Description.

To be a vertical, inverted, direct-acting, surface condensing engine, of the triple-expansion type, having the high-pressure cylinder forward, the low-pressure cylinder aft and the mean-pressure between the two; to be built to withstand a working pressure of......pounds of steam per square inch, and cranks to be set at angles of 120 degrees apart.

CYLINDERS: The high, mean and low pressure cylinders to be respectively ...., ... and .... inches in diameter and each to have a stroke of .... inches; to be of hard, close-grained cast iron .... inches thick, perfectly free from all defects and to be truly bored.

The high-pressure cylinder to be fitted with a separate liner barrel of cast iron as hard as can be properly worked, bolted to the cylinder, and to be fitted with a piston valve; the mean and low-pressure cylinders to be fitted with double-ported slide valves and separate valve faces bolted to the main casting by composition screws. Drain valves to be fitted to the bottoms of cylinders and valve chests and arranged so that they can be operated from the working floor; spring safety valves to be fitted to the receivers and set to .... pounds and .... pounds per square inch, for the low and intermediate, respectively. All stuffing boxes for piston rods and valve stems of main engines to be fitted with metallic packing; brasses to be provided for indicators, etc., and peep holes to be provided in chest for setting valves.

LAGGING: Cylinders and valve chests to be covered with non-conducting material and cased or lagged with black walnut, neatly secured with brass button-head screws; or, if preferred, Russia iron may be used in place of walnut.

CYLINDER HEADS:. To be of cast iron of sufficient depth to give great strength; to be ribbed and covered with polished iron plates.

PISTONS: To be of cast steel, of sufficient depth to give complete strength, to have cast iron packing rings and followers, and to be secured with steel bolts and brass nuts.

PISTON RODS: To be of the best mild steel, well fitted to crossheads and pistons, and secured to each by a large nut.

CROSSHEADS:.To be of wrought iron or steel with crosshead pins forged on; slide box to be of cast iron lined with anti-friction metal and securely bolted to crosshead.

FRAMING: Front column to be of polished forged steel, one to each cylinder, with large flanges forged on at each end, and to be firmly bolted to bed plate and to cylinders. The columns on the condenser side to be of cast iron, box shaped, one to each cylinder, and to be thoroughly bolted to condensers and cylinders; to these cast-iron columns the main guide plates are to be bolted.

CONDENSER:. To be a surface condenser of cast iron, securely bolted to bed plate; to have tubes and tube plates of brass; tubes to be of Muntz metal secured with brass screw glands and cotton cord, each tube to be .... inches outside diameter; a sufficient amount of cooling surface to be provided for condensing purposes, or .... square feet, and also a supplemental feed and cock for soda.

BED PLATE:. To be of cast iron girder or box shape; to be made in two pieces, firmly bolted together, and provided with all flanges, brackets, etc., necessary to bolt it securely to the condenser and foundation. All journals to be .... inches in diameter; boxes to be of brass, lined with the best anti-friction metal, and held in position by heavy steel bolts; caps to be fitted with keepers; each journal to be fitted with a large oil cup.

MAIN GUIDE BARS:. To be of cast iron, box section, securely bolted to the columns on the condenser side and arranged to pass water through them. The outside dimensions of cross-section of these bars to be .... inches by .... inches.

CONNECTING RODS: To be forged of the best mild steel, and to be forked and fitted with two bearings at the crosshead end, each .... inches long; crank pin bearing to be .... inches in diameter; all to be fitted with brass boxes lined with white metal. Bolts, keepers and caps to be of steel or wrought iron, finished bright.

CRANK SHAFT:. To be of the built-up type of the best mild steel; webs of the best hammered iron; shafts .... inches in diameter, provided with the proper couplings and bolts; pins to be .... inches in diameter, all forged in and well keyed together.

SLIDE VALVES: To be of hard close-grained cast iron, accurately surfaced on the slide faces and secured to stem by large nuts and washers; nuts to be of brass and washers of wrought iron.

STOP VALVE: To be a balanced valve not less than .... inches in diameter net; of cast iron body, with valves, seat and stem of brass.

VALVE AND REVERSING GEAR: To be of Stephenson link reversing type, operated by steam; valve stems to be of mild steel, and fitted with brass sliding blocks, with large bearing surfaces; eccentric rods to be forged of the best mild steel or scrap iron with adjustable brass bearings; eccentrics to be of cast iron, in halves, with large bearing surfaces.

STARTING GEAR: Handles for operating throttle valve, valves for admitting steam to each receiver, drain valves and reversing engine, all to be arranged so as to be conveniently operated from the working floor in the engine room.

AIR PUMP:. To be single acting, ... inches in diameter and .... inches stroke; working barrel to be of brass; foot valve, bucket and discharge valves, and guards also to be of brass; to be fitted with hard rubber valves well tested; bucket rod of steel covered with brass sleeve.

CIRCULATING PUMP: To be a centrifugal pump, driven by an independent engine; pump wheel to be of brass .... inches in diameter; shaft in water space to be covered with brass, running in lignum vitae brassings; engine cylinder to be .... inches in diameter and .... inches stroke, and pump to have ample capacity for condensing all steam that boilers will make, after being used by the engine.

MAIN FEED PUMP: To be an independent feed pump driven by an independent engine; to be of the duplex type and sufficiently large to supply all the boilers with water without overworking; to be fitted with composition pistons or plungers, piston rods, valve seats, etc.

BILGE PUMPS: To have two bilge pumps to work from the

air pump crosshead; pump chambers to be of cast iron, plungers of brass, valve seat chest of cast iron fitted with brass valves and seats and air chambers of cast iron.

Pump Gear:. Air and bilge pumps to be connected with one wrought iron or mild steel crosshead, operated by links and beams from the main crosshead of the engine; beams to be formed of double plates of wrought iron or steel; both front and back links to be fitted with brass boxes adjusted by gibs and keys.

Power Turning Gear: To consist of a large cast iron worm wheel, driven by an independent engine; the worm engine to be fitted with reversing gear.

OR,

Hand Turning Gear: To consist of a large cast-iron wheel fitted on after coupling; rim of wheel to be fitted for pinch bar.

Shafting: Crank and outboard or propeller shaft to be .... inches in diameter, of steel, and intermediate or line shafts, ... inches in diameter; couplings for all shafts to be forged on; propeller or outboard shaft to have brass sleeve at stuffing box and at the stern bearing and between these sleeves to be covered with a copper pipe made water-tight at its junction with each sleeve.

Thrust Bearing: To be of the horseshoe pattern; pedestals to be of cast iron, the ends and side walls of each of which will form a trough; the horseshoes, ... in number, to be made of cast steel, lined with white metal and properly channeled for oil; brass adjusting nuts to be provided on the steel side rods, and attention to be paid to securing an efficient distribution of oil on the thrust surfaces.

Steady Bearings: One steady bearing to be provided for each section of shaft, to be of cast iron lined with best lining metal and to be fitted with caps and bolts.

Stern Tube Bearing: Stern pipe to be of cast iron, secured to the stern post by a large wrought-iron nut and to the stuffing-box bulkhead by a large flange, securely bolted to same; pipe to be supported in two places between the stern port and stuffing-box bulkhead; stern bearing to consist of a brass bushing filled with lignum vitae, the bearing to be .... feet long; forward end of stern pipe to be a long bearing with stuffing box at the end.

Propeller Wheel: To be of cast steel or other approved material and secured to the shaft by feather and nut, which is to be covered by a fair water cap properly bolted to hub of wheel.

Steam Pumps: To be of the best commercial pattern; one pump to be provided for the donkey boiler, of a capacity of .... gallons per minute and .... fire pumps and .... independent feed pumps, each to have steam cylinders .... inches in diameter and .... inches stroke, and water cylinders .... inches diameter and .... inches stroke; a water service pump to be provided for salt and fresh water tanks in the upper engine room for water closet and drinking purposes, the steam and water cylinders to be respectively .... inches and .... inches diameter and .... inches stroke; all of the above pumps to be of the duplex type; the fire pumps to be arranged to pump from bilge, boilers and tanks, and also fitted complete for fire purposes; feed pumps to be arranged to pump from hot well and fresh water tank; all pumps to have brass lined barrels, plungers of composition and valve seats of brass, arranged for pumping both salt and hot water.

Sea Connections: A sea valve to be provided for the circulating pump, the fire pump and the jet injection and water service pump; an outboard delivering valve for the air pump, the circulating pump and the bilge pump; all valves to have cast iron bodies with brass valve seats and stems; all sea valves to be provided with the proper gratings.

Pipe and Valves: All steam and water pipes of 2 inches diameter and above to be of copper; those below 2 inches in diameter to be of brass; bilge suction pipes to be of lead; all necessary strainers, etc., to be provided and fitted in place; all valves above 2½ inches in diameter to have cast iron bodies, brass valve seats and stems; all valves below 2½ inches in diameter to be entirely of brass.

Oil and Water Service: A complete lubricating arrangement to be fitted to all the bearings of the engine, and efficient lubricating devices to the minor moving parts, fed from tanks near the top of the engine; also a complete water service to all the main bearings, guides, thrust bearings and steady bearings.

Injectors: To be of ample size to furnish the boilers with water.

Packing: The piston rods of the high-, intermediate-, and low-pressure cylinders and all valve stems to be packed with approved metallic packing; all packing to be approved before installation.

Platforms, Ladders and Gratings: All working and other platforms, stairways and railings to be fitted as directed by the inspector; the lower floors of the engine and fire rooms to consist of ribbed steel plates and all gratings to be of steel; the ladders in the fire room to be of steel with figured cast iron treads; the railings in fire rooms to be of wrought iron pipe and those in engine room of brass polished, with brass knobs.

Indicator Gear: A complete indicator gear to be furnished and fitted in place on each cylinder, ready to attach indicators; indicators not to be furnished.

Gages and Clocks: In each engine room there is to be furnished and neatly fitted in place one main steam gage, one gage for each receiver, one counter, one vacuum gage and one clock—all to be of brass, nickel plated, and to have 8½-inch faces; in the fire room each boiler is to be provided with a gage of 5¾-inch face with japanned iron case, and also a steam gage for the donkey boiler.

Bells: One gong of satisfactory size to be provided in each engine room, and jingle bells, bell pulls, etc., and speaking tubes, all to be provided and fitted in place ready for work.

Traveler Bar: A traveler bar to be furnished and fitted to place for lifting cylinder heads; also eyebolts and carriers for disconnecting the different parts of the machinery.

Painting: The machinery is to be well painted with such colors as may be desired.

General Clause: The machinery is to be set up in the vessel and well fastened, and everything furnished to complete the same, together with all necessary tools, wrenches, etc., ready for service and to pass U. S. inspection laws; all to be of the best material and the work to be done in a first-class workmanlike manner the general arrangement of pipes and machinery to be similar to that of the steamer ....

General Specifications.

1. All castings must be sound and true to form, and before being painted must be well cleaned of sand and scale, and all fins and roughness removed.

2. No imperfect casting or unsound forging shall be used if the defects affect the strength or to a marked degree its slightness.

3. All flanges of castings must be faced and those coupled together will have their edges made fair with each other; the faces of all circular flanges to be grooved.

4. All bolt holes in permanently fixed parts must be reamed or drilled fair and true in place, and bolts furnished of bodies to fit them snugly.

5. All material used in the construction of the machinery must be of the best quality, the iron castings to be made of the best pig iron and not scrap, except where otherwise directed.

6. The Muntz metal must be of the best commercial quality.

7. The anti-friction metal must be of an approved kind.

8. All castings must be increased in thickness around core holes; core holes must be tapped and core plugs screwed in and locked, except where bolted covers are used, or where it may be directed that the holes be left open.

9. All steel forgings must be without welds and free from laminations.

10. All flanges, collars and offsets must have well rounded fillets.

11. All steel used in the construction must be tested in accordance with rules prescribed by the inspector.

12. One set of wrenches must be furnished complete; the wrenches for all nuts of bolts less than one inch in diameter

to be finished, and for all bolts over two inches in diameter to be box wrenches, where such can be used; socket wrenches to be furnished where required; open-end wrenches to be of steel or wrought iron with case-hardened jaws; all others of wrought iron or cast steel.

13. All brasses or bearings must be properly channeled for the distribution of oil.

14. Packing for stuffing boxes must be such as may be approved.

15. All small pins of working parts must be well case-hardened.

16. The auxiliary engines and all fittings and connections subjected to boiler pressure must be tested by water pressure to .... pounds to the square inch; after boilers are placed in the vessel and connections made, the boilers and pipe connections must be tested by steam to .... pounds per square inch.

17. All pressures to be above atmospheric pressure, and *not* absolute pressures.

18. All places where condensed steam can accumulate must be provided with drain pipes and cocks or valves of ample size, and with approved automatic traps; all traps to have by-pass pipes and valves for convenience in overhauling; the lowest parts of all water pipes and all pump cylinders and channel ways to have drain cocks with pipes, where required; the handles of all drain cocks to point downward when closed; all glass water gages under pressure to be fitted with valves of approved automatic closing patterns.

19. A copy of each working drawing must be furnished to the inspector before the work shown by that drawing is commenced.

20. All work must in every respect be of the first quality and executed in a workmanlike and substantial manner.

21. Any portion of the work found defective must, whether partially or entirely completed, be removed and satisfactorily replaced without extra charge.

22. Wherever duplicate pieces are furnished for one or two or more pieces of machinery of the same size, they must be made strictly interchangeable.

23. The steam cylinders of all auxiliary engines must be clotted with approved incombustible non-conducting material and lagged with Russia sheet iron; the non-conducting material to be the same as that used on the main engines.

24. Composition castings must be made of new materials, the various compositions to be by weight as follows: For all journal boxes and guide gibs, where not otherwise specified, Copper, 6-parts, Tin, 1-part and Zinc, ¼-part; for composition not otherwise specified, Copper, 88-per cent., Tin, 10-per cent. and Zinc, 2-per cent.; for Naval Brass, Copper, 62-per cent., Tin, 1-per cent. and Zinc, 37-per cent.

25. All working parts of machinery must be fitted with efficient lubricators, each with a sufficient oil capacity for four hours' running.

26. All iron boxes must be bushed with composition, and all glands must be of composition.

27. All bolt heads and nuts less than 3 inches must, except in special cases, conform to the United States Standard; screw threads on bolts and nuts must in all cases conform to the above standard; all finished bolts must, except as directed, be kept from turning by dowels or other suitable devices. The nuts of all bolts on moving parts, on pillow blocks, etc., as shown, must be locked, and the bolts must extend beyond the nuts, without threads, and be fitted with split pins. This specification is extended to apply to all pumps and auxiliary engines, as well as to parts of the main engines and boilers.

28. Each safety valve and each relief valve must have a spare spring; other spare parts for all special machinery must be supplied as directed by the inspector.

Tools.

The tools necessary for the engineer to be furnished as follows:

6 Spare glasses for water gages.
1 Set of fancy oilers and stand.
6 Squirt cans.
3 Quart feeders.
3 Funnels, assorted sizes.
1 Vise and bench.
Stocks, taps and dies, ¼ inch to 1 inch.
Ratchet and drills, assorted sizes.
12 Chisels, assorted.
2 Copper mauls, one for large and the other for small keys.
4 Hand hammers.
3 Monkey wrenches, 8, 12 and 18 inches.
1 Sledge.
1 Coal maul.
Necessary iron blocks and falls for hoisting machinery, and iron blocks and falls for cylinder heads.
Complete set of packing hooks and screws for all glands.
Necessary packing hooks for condenser.
Necessary wrenches for engineers' use.
Set of wrenches to be finished and set in walnut rack.
2 Pairs of pipe tongs, ⅝ inch to 2 inches.
3 Hose spanners for 2½-inch N. Y. Standard hose.
2 Scaling picks.
Set of scaling bars or chisels, assorted.
Two tube brushes and handles.
Hose for wetting ashes, 2 sections of 10 feet each.
One pair dividers, 6 inches.
1 Gallon measure.
1 Pair calipers.
1 Pair pliers, 6 inches.
1 Wire cutter, 6 inches.
1 Hand punch for iron.
6 Steel wedges.
1 Pair shears for sheet tin.
2 Pairs smiths' tongs.
1 Center punch.
1 Sight feed oil cup for the high-pressure cylinder.
1 Tallow cup for the intermediate and low-pressure cylinders.
1 Thermometer for feed water.
1 Salinometer.
1 Screw jack, 12 inches.
2 Oil tanks, 65 gallons each.
1 Waste can, 20 inches in diameter and 32 inches high.
1 Tallow can, 18 inches in diameter and 24 inches high, with ½-inch lid.
1 Set of caulking tools (boiler maker's).
2 Reamers (boiler maker's).
6 Files and handles, assorted.
1 Brace and bits, assorted.
1 Hand saw.
1 Lock saw.
1 Jack plane.
1 Hatchet.
2 Screw drivers, one large and one small.
6 Chisels and gouges.
1 Key wrench.
1 Grindstone.
1 Hand chisel (smith's).
2 Lockers for holding tools.
One full set of fire tools, viz:
4 Slice bars.
4 Hose.
2 Clinker hooks.
2 Pricks.
4 Shovels.
4 Lazy bars.
2 Ash buckets.

* * *

The practice of mounting blueprints on boards, sheet iron or pasteboard and shellacking them so as to better withstand grease, water and the other exigencies to which they will likely be subjected in the average shop, is well-known—better probably than the method of waterproofing unmounted blueprints that has been recently described in some of our exchanges. A number of sheets of absorbent cotton, about a foot square, are dipped in melted paraffin until thoroughly saturated; when withdrawn and cooled, they are ready for use. One of the saturated cloths is spread on a smooth surface, the dry print is placed on it, and a second waxed cloth on top. The whole is then ironed with a moderately hot flat-iron. The paper immediately absorbs the paraffin, and becomes translucent and waterproof. The lines of the print are intensified by the process, and there is no shrinking or distortion. As the wax is withdrawn from the cloths, more can be added by melting small pieces directly under the hot iron. By immersing the print in a bath of melted paraffin, the process is hastened, but the ironing is necessary to remove the surplus wax from the surface, unless the paper is to be directly exposed to the weather and not to be handled.

Blueprints treated in this way are said to be so impervious to moisture that they may be safely used out doors in damp weather, in mines and in other places where ordinary untreated blueprints would soon be ruined.

MOTOR DRIVEN TRUCK HAVING NOVEL VARIABLE SPEED MECHANISM.

At the late automobile show, held in Madison Square Garden, there was a sad lack of motor-driven vehicles for industrial purposes, that is, trucks. With a very few exceptions, all the machines exhibited were for pleasure, and most of them for pleasure of a very expensive kind, at least in the matter of first investment. One of the exceptions was a truck built by the Union Motor Truck Co., of Philadelphia, and so far as we are aware, it was one of the most interesting machines, mechanically, in the whole show. It has what no other one possessed, a variable-speed mechanism by which the speed can be varied at will of the driver from zero to the maximum, by minute increments, making it possible to vary the motion to any imaginable degree from nothing to full speed. The same holds for going backward. The leverage or "power" with which the truck is propelled varies in inverse ratio, being theoretically infinite at the slowest speed, which practically means, of course, that the truck is not propelled at all.

The truck has an internal combustion type motor with 4 cylinders 5 x 6½ inches stroke, connected to one crankshaft and developing 20 horse power at 400 revolutions per minute. The engine is located directly beneath the center of the truck platform and is connected to the rear axle by means of three rods, which take hold of three reversible roller ratchets. All three connecting-rods are connected to one crank-pin, which is located in the face of the flywheel. Means are provided for moving the crank-pin from the center and thus giving the connecting-rods a variable movement, which, being transmitted through the roller ratchets, gives the rear wheels a degree of angular motion for each stroke of the engine dependent upon the distance the crank-pin is moved from the center. The engine may run all the time at the uniform speed of about 400 revolutions per minute. When the crank-pin is on the center, no movement is communicated to the ratchets, consequently none to the wheels. From this it is obvious that no clutch is required in the construction, aside from that provided by the roller ratchets themselves, since the engine can be started without load by simply moving the crank-pin to the center of its throw, which is always done.

The accompanying diagram, Figs. 1, 2, and 3, give an idea of the construction of the variable-speed gear. The crank-pin *H*, is shown in the center of the flywheel, in which position no motion is transmitted. The dotted lines show the relative positions of the parts when it is moved off the center to the position indicated by *H'*. Two of the connecting-rods, *A* and *B*, transmit the power longitudinally to the arms of the ratchets, *E* and *G*. The third rod, *D*, acts as a lever, having its pivot near its center. The short link *C* connects one end to the crank and the link C_1 connects the other end to the arm *F* of the third ratchet. The diagram shows the rollers *K* of the ratchets, in their neutral position, that is, no engagement is possible to drive in either direction. They are held in this position and the driving positions by means of a bronze cage *L*, which contains 60 slots for the rollers, of which there are 20 in each ratchet, all lying in the same longitudinal grooves cut in the hardened steel center piece, *I*. The center piece *I* is securely keyed to the sleeve *M*, which is mounted on the axle *O*. The bronze cage is loosely fitted on the steel center and rotates with it, being carried along by the two keys *N N*. These keys may be moved longitudinally, from the driver's seat, and when so moved a spiral feather on top of each, advances or moves back the cage, depending on whether a forward or backward motion is required. Movement in either direction throws the rollers in position to be gripped by movement of *J* in one direction and to release in the opposite direction, thus acting as ratchets having teeth of any desired pitch.

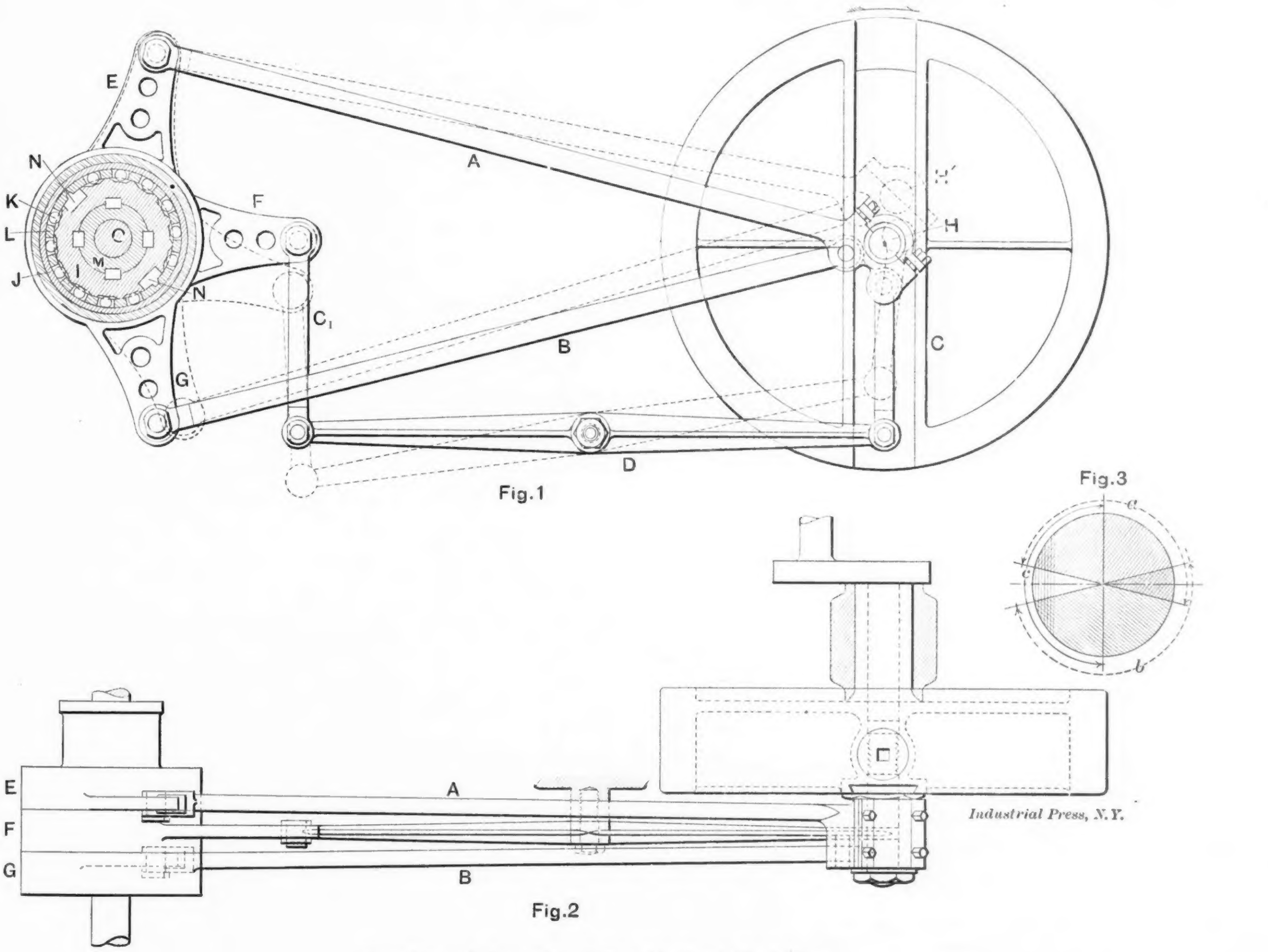


Fig. 1 Fig. 2 Fig. 3

Elevation and Plan of Truck Variable Speed Mechanism.

The rollers are made of tool-steel, hardened, are ⅝ inch in diameter and project above and below the cage about 1-16 inch, so as to be gripped between the ring *J* and the grooved center *I*. The longitudinal grooves are about ⅛ inch deep by ¾ wide at the base, with the sides flaring to a width of 1⅜ at the periphery. The sides are ground to an angle of about 10 degrees, varying with the diameter of the center. All the

rollers take their proportionate share of the load so the pressure on each one is not great. Four years of use have demonstrated that the outer rings and rollers wear round, the seats in *I* alone requiring regrinding every six months or every year, according to the amount of work done.

The diagram shown in Fig. 3 shows the travel of the crank-pin and the portions of its travel during which each ratchet is in action. The arc designated *a* indicates the distance

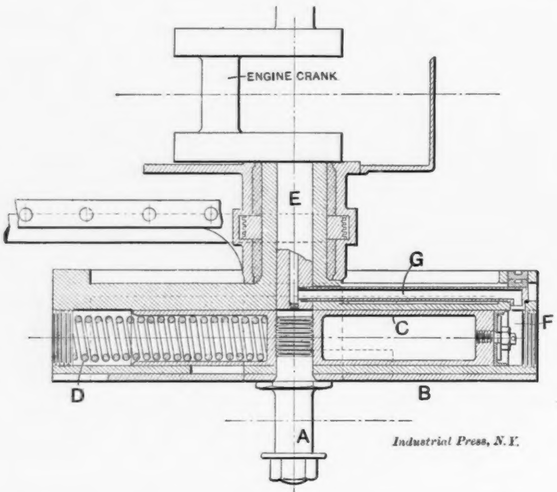


Fig. 4. Section of Flywheel showing Hydraulically Operated Crank-pin.

through which motion is imparted by the working stroke of the upper rod *A;* *b*, that of the rod *B;* and *c*, that of rod *D*. The single-hatched portions of the diagram indicate the parts of the travel where one rod alone is driving and the cross-hatched portions are those portions of the travel where two rods are working together, or rather where their work overlaps, one releasing while the other is beginning to drive. Thus there is no point at which the rear axle is not receiving motion from the engine, and motion of a quite uniform character being a fair approximation to straight line, when plotted.

Fig. 4 shows the construction of the flywheel by which the crank-pin is moved to and from the center. The pin *A* is screwed into a hydraulic piston *C*, which moves in a cylinder bored in the flywheel parallel to its face and passing through the center. The movement of this piston is resisted by the coiled spring *D*, which returns it and the crank-pin to the center when pressure behind the piston is removed. The oil by which it is operated, is pumped into the space *F*, reaching it by means of a hole that passes through the whole length of the crankshaft, cranks and all, and terminates at a stuffing box on the opposite end. A small pump driven from the engine by gearing forces the fluid behind the piston when thrown into engagement by the driver. Normally this pump is out of engagement. The movement communicated to the crank-pin is comparatively slow, so that the acceleration cannot be suddenly increased when starting. After the required throw has been obtained the piston remains oil-locked in position. To stop, the driver pulls a lever which opens a small valve, and allows the crank-pin to move quickly or slowly to the center by the action of coiled spring *D;* a further movement opens a large valve which allows the crank-pin to move quickly to the center; and still further movement of the lever applies a powerful band brake on the differential gear frame.

The running gear of one of these trucks is shown in Fig. 5, from the flywheel side of the engine. The photograph was taken with the crank-pin in the center of the wheel. The three connecting-rods and ratchets are shown; also the differential gear on the further side next to the rear wheel. Motion is conveyed to the bevel gear frame carrying the bevel pinions in the center, by means of a sleeve supported by the shaft *O*, Fig. 1, and attached to the central portion of the differential. From this, motion is communicated back through the shaft or axle *O* to the driving wheel on the side of Fig. 5 toward the reader, and directly to the wheel on the opposite side by means of the bevel gear being attached to the wheel hub itself. The axle is projected through this wheel so as to form its support but not to drive it.

* * *

SHORT RULE FOR COMPUTING SAFE FLYWHEEL REVOLUTIONS.

Wm. H. Boehm gives the following short rule in the Monthly Bulletin of the Fidelity and Casualty Co. for computing the safe number of revolutions for a flywheel.

The rule is based upon the current practice of allowing a rim-speed of one mile per minute for well-made cast-iron wheels, and so does not take into consideration the difference in strength between solid and sectional wheels.

Rule: To compute the maximum allowable number of revolutions per minute for cast-iron wheels, when given the diameter of the wheel in feet. *Divide the number* 1680 *by the diameter.* This is expressed in the form of a formula as follows:

$$\text{Maximum revolutions per minute} = \frac{1680}{D}$$

Example: What is the maximum allowable number of revolutions per minute for a well-made cast-iron wheel 16 feet in diameter? Here we have

$$\text{Maximum revs., per minute} = \frac{1680}{16} = 105.$$

That is, a 16-foot cast-iron wheel should never be run faster than 105 revolutions per minute.

* * *

One of the brightest and best of the English mechanical publications that come to our desk, is *Page's Magazine*, now in its second year of publication. It is not insular in its policy and because of its liberality in publishing foreign mechanical news, especially that from the United States, the publishers say it has been accused of being an American publication. "This is doubtless due to the singular fact that kindred publications which have attained to prominence on this side of the Atlantic have been, for the most part, of American origin, being edited and printed in the United States, shipped over here without covers to escape the imprint 'Made in America,' bound up with English advertisements, and circulated as home publications."

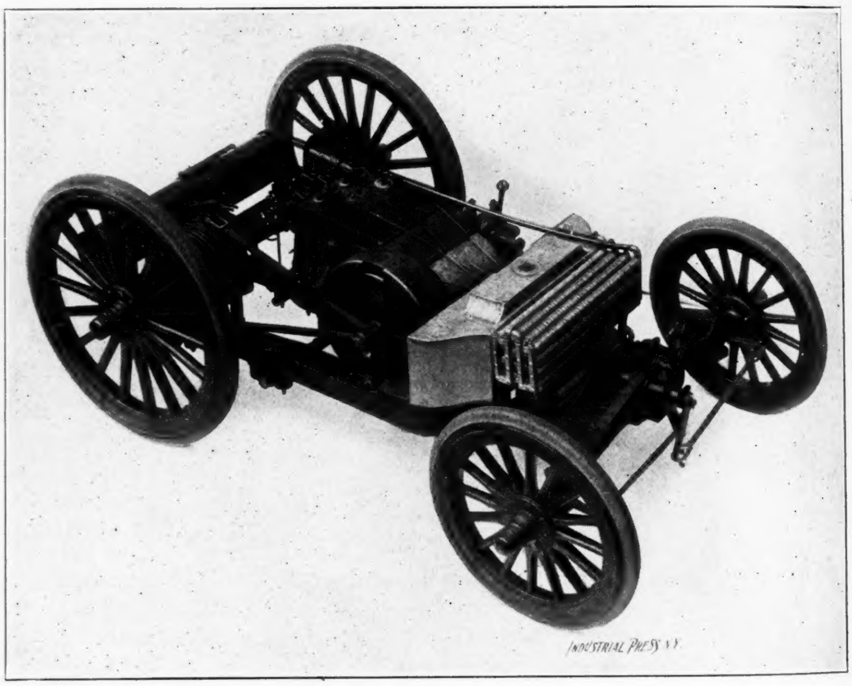


Fig. 5. Running Gear of Union Motor Truck.

LOCOMOTIVE DRIVING WHEEL LATHE WITH SPECIAL FEATURES.

A few months ago James K. Cullen, president of the Niles Tool Works Co., read a paper before the Western Railway Club, in which he referred at some length to a locomotive driving wheel lathe having certain new features, which was built by his branch of the Niles-Bement-Pond Co. for the Altoona shops of the Pennsylvania Railroad. The new lathe, which is thought to mark a considerable advance in this class of railway shop tools, is illustrated in Fig. 1, and details of the magnetic clutch—an important feature of the design—is shown in Fig. 2.

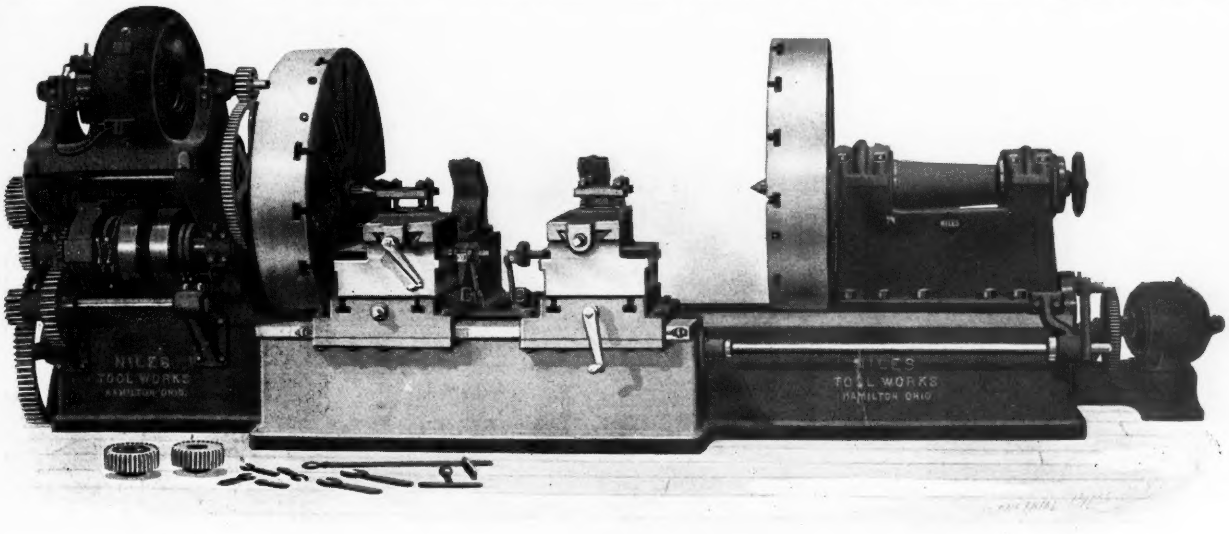


Fig. 1. New Driving Wheel Lathe having Important Improvements.

The lathe was designed to accomplish the maximum output of turned tires now possible with the new high-speed steels. To secure this result, it is necessary to have a much heavier and stiffer construction than heretofore employed in this class of machines; also to provide a more powerful drive and means for instantly reducing the speed to a very slow rate when cutting out "hard spots." One cause for lack of rigidity in the common driving wheel lathe, is the overhang of the internal sliding spindles necessary on account of the crank-pins. To overcome this fault a feature of construction was adopted that would scarcely be feasible without using an auxiliary motor to move the headstock back and forth along the bed, and that is, providing openings in the faceplates for the crank-pins. In this way short centers close up to the faceplates can be used instead of having a long overhang of the internal spindles, as is usual. This construction, of course, makes it necessary to move the right-hand headstock, whenever a pair of wheels is put in and taken out of the lathe, which is done by the 3 horse power auxiliary motor shown at the right. The motor makes the movement of the headstock necessary to clear the crank-pins an easy matter. The final adjustment of the center is made by the internal spindles in the headstocks operated by hand-wheels in the usual manner.

The lathe is driven by a General Electric 25 horse power motor mounted on top of the left-hand headstock. The motor has a range of speed from 600 to 840 rotations per minute and this variation, together with the change gearing that can be introduced in the train of gearing between the motor and the pinions meshing into the internally-geared faceplates gives ordinarily a range of peripheral speed at the tire surface, of 10 to 30 feet per minute. Power is conveyed from the motor to the faceplates, through the magnetic clutch shown beneath the motor in Fig. 1 and in detail in Fig. 2. The object of this device is to provide means for instantly reducing the cutting speed from the normal down to from 4 to 6 inches per minute, depending on the speed of the motor. This slow speed is employed to cut out the hard spots that are developed by skidding tires, etc.

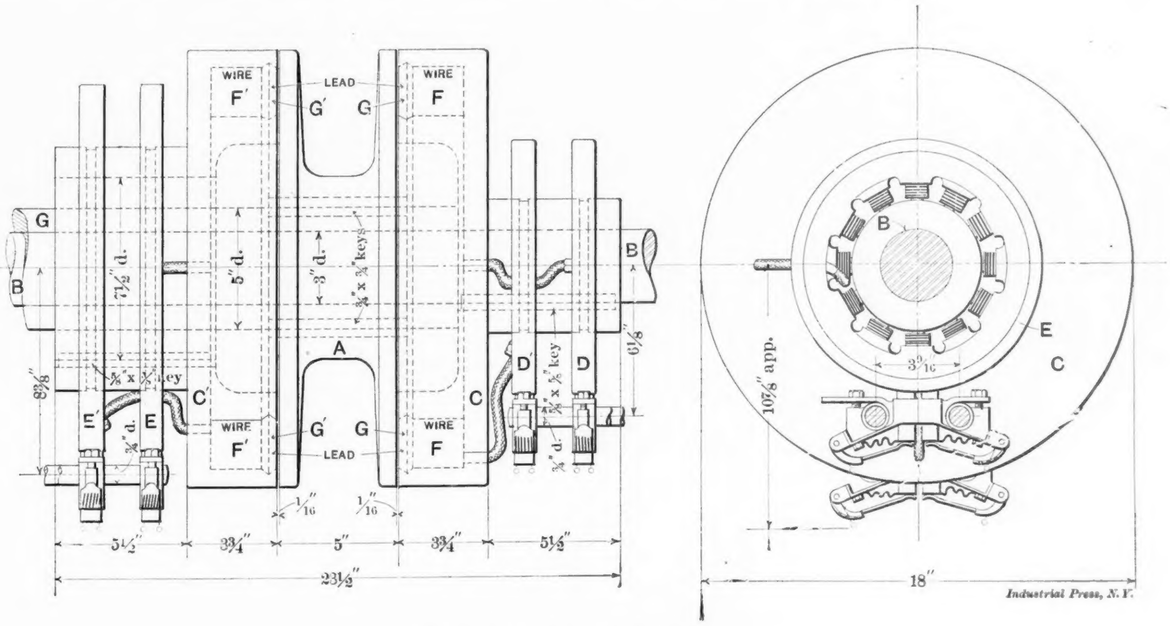


Fig. 2. Details of Magnetic Clutch.

The magnetic clutch by which this great change of speed is effected, consists principally of the spool-shaped steel piece *A* and the two magnets *F* and *F'*. The latter are made with annular grooves for the magnet wire, and the grooves are undercut near the faces for lead filling, *G* and *G'*. The lead filling holds the magnet wire in place and also prevents the faces of

the armature A and the magnets coming intimately in contact, which precaution appears necessary to prevent sticking due to "residual magnetism." Otherwise a quick change of the armature from one magnet to the other could not be effected easily. $D D'$ and $E E'$ are collector rings for conveying current to the magnet terminals. Normally the lathe is driven through the magnetic clutch medium with A (keyed to the quill G) attracted to the right against clutch C, which is keyed to shaft B. To reduce to the very slow speed, the left-hand magnet C' is energized by the operator simply throwing a switch, and the armature is attracted to it. The drive is then through the bevel gears seen beneath the motor, and a worm gear, the worm-wheel (covered by the casing) being mounted on the hub of C'. In this way the speed is reduced and at the same time the pressure developed on the tools is enormously increased—two conditions necessary for successfully cutting hardened steel.

Each tool rest can carry two tools and the design of the lathe is such that a pressure of 18,000 pounds can be developed at each tool rest. All gears are made of gun iron and steel. The main spindle bearings are 13 inches diameter and 16 inches long. The internal sliding spindles, 7 inches diameter, are made from steel forgings. The faceplates are 72 inches diameter and have internal gears of 2 inches circumferential pitch. The total weight of the machine is about 80,000 pounds.

* * *

LIGHTNING CLOSES DOWN NIAGARA FALLS POWER PLANT.

(Special Correspondence.)

The most disastrous accident which has ever happened to the Niagara Falls Power Co.'s plant, interfering with its transmission of power to Buffalo and the surrounding towns, occurred Thursday evening, January 29th. An electric storm passed over Western New York, with heavy thunder and lightning, the temperature being high, and yet within a few hours a snow storm followed with a corresponding lowering of the temperature.

The lightning struck a local 2,200 volts line of the Niagara Falls power plant, forming a short-circuit in the cable bridge through which all of the conductors are carried, connecting the 5,000 horse power generators in the power house with the static step-up transformers in the transformer house across the canal. The roofing of the cable bridge and the transformer house being of wood was instantly on fire and all of the cables crossing the bridge were totally destroyed, shutting down the entire plant of 50,000 to 75,000 horse power.

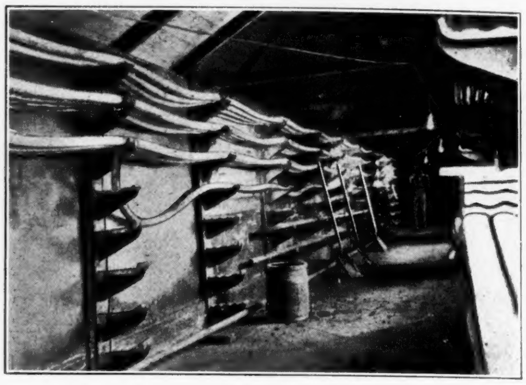
The new power house has five 5,000 horse power generators in place and in operation, but the temporary connections made with the transformer house were interfered with by the fire, resulting in a complete closing down of the generators. In extinguishing the fire large quantities of water were poured into the transformer house, completely deluging the static air cooled transformers and making them useless, until they could be thoroughly dried out.

Fortunately, there was a large stock of high tension lead-covered cable on hand, which was being used for the new power house work, and this was immediately pressed into service. Superintendent Philip P. Barton and his engineers were soon at work, and before morning thirty-six new cables were in place and a new roof was constructed for the transformer house and bridge, and four 5,000 horse power alternators were placed in operation.

It will undoubtedly be some time before the entire plant is in perfect working order again, but most of the power users were supplied with current before Friday night. Probably no other accident could be imagined which would so completely disable the entire Niagara power plant as the burning out of the cables in the bridge conducting the current to the transformer house from the ten 5,000-horse power generators in power house No. 1.

The accompanying photograph shows the interior of the transformer house and conductor bridge with its new roof and cables in place the morning after the fire, with 20,000 horse power being generated in the two power houses. While this was a most satisfactory piece of emergency work, it might have been impossible to accomplish had the new cable not been ready for the new power house construction, although it is stated a large stock of this highly insulated lead-covered cable is constantly kept on hand.

It was of course a most serious matter for many of the users of Niagara power, as many of them operate their plants day and night, and a shut-down of even a few hours is very disastrous. This is particularly so in reference to many of the electro-chemical plants using electric furnaces, and also of factories where many men are employed. The power plant of the Niagara Falls Hydraulic and Mfg. Co., which obtains its power from a surface canal through the city of Niagara Falls, was able to give great assistance during this serious trouble, to local users.



View of Tunnel after Fire, showing Burned Timbers, New Roof and New Cables

The original power house with its 50,000 horse power and the five new generators already installed of 25,000 horse power capacity in power house No. 2, make a total of 75,000 horse power available when the full plant is in operation. This power is not only used for lighting Niagara Falls, Tonawanda and Buffalo, but it also practically operates all the railways in Western New York, as well as a large proportion of the electro-chemical works and factories on the Niagara frontier.

The street railways service and the lighting service of the city of Buffalo were greatly affected by the accident at the power plant. The large storage batteries of several thousand horse power hours' capacity carried the load for a short time, but they were soon exhausted under the heavy discharge. The street railway storage battery was utilized until the large reserve steam plant could be placed in operation, but the car service was badly crippled until the Niagara power was again ready for transmission, although the car lines were never entirely shut down.

The Cataract Power and Conduit Co., however, were not so fortunate as to have a steam plant available, and they could furnish no current to their customers. The Buffalo General Electric Co., and many of the manufacturers were unable to get power until late Friday, which caused much inconvenience. For this reason many of the newspapers were unable to operate their presses, and the three newspapers having reserve steam power, the News, Express and Commercial, aided the Times, Courier and Enquirer.

The fifteen 5,000 horse power generators, and all of the apparatus of both power houses No. 1 and No. 2 are in perfect condition, the reports to the contrary notwithstanding, and only a very small proportion of the static step-up transformers were damaged in any way by fire or water. The lightning did not strike the high tension lines of 22,000 volts, but the damage was confined to the 2,200 volts cables connecting the transformer house and power house No. 1.

This disastrous fire at the Niagara power house shows how much care should be taken with the apparatus for protection against lightning and the desirability of using fireproof materials exclusively in every portion of an electric plant. The duplicating of transmission lines is now extensively practiced and is undoubtedly advisable, and unquestionably engineers of the new Niagara power plants on both sides of the river will consider the causes of this serious shut-down in all their phases and endeavor to make such an accident impossible in the future.

As the other power stations are installed the liability of a

complete shut-down will become less and less, as power may be transferred from one power house to the other. The unexpected happened in this case, and there is little liability it will ever happen again. A second conductor bridge with duplicate cable would have rendered the accident less troublesome, as "all the eggs would not have been in one basket" and the current could have been conducted to the transformer house through the duplicate sets of cables. It is also questioned by some prominent engineers whether it is desirable that all of the transformers of a 50,000 horse power plant should be placed in a single building, as the burning out of one set of transformers may affect many others.—F. C. P.

* * *

THE DATA SHEET FOR THIS MONTH.

The data sheet accompanying this month's issue of MACHINERY presents a diagram for designing band brakes that was computed by Mr. C. F. Blake, Muskegon, Mich. The directions accompanying this sheet adapt it for use in designing band brakes having arcs of contact from 20 to 300 degrees. The diagram, as prepared, considers the coefficient of friction as equal to 0.3, while the table of directions supplies formulas for calculating the desired quantities with any coefficient.

Assuming a problem to illustrate the use of the chart, let us suppose a force $P = 1{,}800$ pounds is to be held by the brake, having an arc of contact of 180 degrees; coefficient of friction of .3; length of arm $b = 4$ inches and force applied by the operator $= 128$ pounds; what is the required length of the arm a?

Starting at 1,800 pounds under $f = .3$, follow up to the 180 degree line, thence to the right to the line representing $b =$ 4 inches, thence down, meeting the horizontal line from 128 pounds on line representing a=36 inches. This will be the length required. Looking in the column headed T_1 we read 1,150 pounds, which is the pull upon the loose end of the strap. This multiplied by k=2.56, obtained from the table opposite 180 degrees and under f= .3, will give T_2 the pull upon the tight end of the strap as 2,944 pounds.

Upon the third page of the sheet is a diagram for determining the weight of cast iron pulleys. This diagram was prepared, and the formulas deduced, by Mr. William Sangster, Jamaica Plains, Mass., and is the result of an investigation of a very large number of pulleys of acceptable design. The lines are the result of two factors—one a constant for each diameter and the other a factor of diameter and face. It may readily be seen that an equation, probably varying as the square of the diameter, would give the weight of arms as a constant for each diameter of pulley, and this equation is expressed by

$$.0362\ D^2 - 2.$$

The rims on the larger pulleys are thicker than those on the smaller ones, and the equation

$$.0175\ D^{1.87} + 3.$$

gives the weight of rim for each inch of width. D in each of these equations represents the diameter of the pulley in inches. The combined equations

$$.0362\ D^2 - 2 + (.0175\ D^{1.87} + 3)\ W.$$

where $W =$ face of pulley in inches, will be found to be fairly accurate for estimating pulleys from 10 to 42 inches in diameter. Pulleys under 10 inches in diameter easily vary from 100 to 200 per cent. in weight, owing to the various sizes of shafts with their corresponding diameters of hubs, so that the diagram and formulas are not to be used for close approximations for pulleys under 10 inches in diameter.

The table of geometrical progression which appeared in the February number of MACHINERY has been put into data sheet form, for the convenience of the draftsman and designer, and forms the fourth page of the sheet for this month.

* * *

Radium, the curious and wonderful element which seems to possess intrinsic energy and emits light without loss of energy, so far as discovered—the next thing to perpetual motion—sells at the rate of $900,000 a pound, although we do not know that there is so large a quantity as this available at the present time. If it is true, however, that its energy is inexhaustible and as a substance it is indestructible, it would be cheap at any price, considered as an investment.

THE EFFICIENCY OF MECHANISM.*

WITH SPECIAL REFERENCE TO HOISTING MACHINERY.

C. F. BLAKE.

When undertaking the development of any machine the designer is promptly brought to face the question of the probable efficiency of the mechanism he wishes to employ. If the machine belongs to a class with which the designer has been long familiar, he may be able to judge closely from past experience as to what efficiency to assume in his present calculations. If the designer cannot bring to his aid such past experience, he may be told by the chief engineer to assume a particular value for the efficiency. Failing in both past experience and the availability of the chief engineer, the designer may attempt a wild guess, more or less remote from actual conditions, possibly seeking information from a handbook, where he may find something like the following, from D. A. Low's Pocket-book for Engineers:

Mechanical efficiency of machines.

P = force acting at the driving point,

W = force acting at the working point,

r = velocity ratio of the machine, $= \dfrac{\text{velocity of working point}}{\text{velocity of driving point}}$

p = value of P when $W = O$,

e = a coefficient,

E = mechanical efficiency of the machine.

When friction is neglected $\dfrac{P}{W} = r$,

when friction is taken into account $P = (1 + e)\ Wr + p$.

For a particular machine the preceding equation reduces to $P = mW + k$, where m and k are constants determined from experiments with the machine.

$$E = \frac{W r}{(1 + e)\ W r + p} = \frac{W r}{m w + k}$$

This is exceedingly disappointing, as the inconvenience of experimenting with a particular machine yet unbuilt, with a view of determining constants to be used in calculations during its design, is apparent. Consequently the aforesaid wild guess is too often used as a basis from which to calculate the probable performance of the machine.

The determination of the efficiency of any elementary portion of a machine by analysis is a comparatively simple matter, and by roughly dividing the proposed machine into several such elementary portions, and determining by analysis the efficiency of each element, the approximate efficiency of the whole machine may be determined. The following analysis of some simple portions of machinery may easily be extended by the application of the same reasoning to other cases, and the tables may form a guide for an intelligent guess which will come nearer the truth than a wild guess.

Efficiency Defined.

The force exerted to run any kind of machine is used in the performance of two functions: To perform the intended useful work for which the machine is designed; and to overcome the frictional resistances in the several parts of the machine. If the machine could be considered as running with absolutely no frictional resistance between its moving parts, we should have the product of force into space moved equal to the product of load into space moved; or

$$P_1 s = L h, \quad P_1 = \frac{L h}{s} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

in which $P_1 =$ the theoretical force, which acting through a space s, will move a load L a certain distance h, under the assumption that there are no frictional resistances in the machine.

The force exerted through the space s, must, however, overcome the frictional resistances within the machine, as well as the resistance of the load L through the distance h. Let $W =$

* This article will be completed in two installments, of which this is the first. The present installment considers the efficiency of simple pulleys and sheaves and of ropes, with a discussion of general principles. The concluding installment will take up the efficiency of tackle, gears, winding drums and finally a complete hoisting apparatus, which will include the various elements previously treated.—EDITOR.

the sum of all the frictional resistances within the machine, and w = the sum of all the distances through which the several frictional resistances are overcome. Then Ww = the work done in overcoming the frictional resistances of the several parts of the machine. The actual force, acting through a space s, besides being required to move the load a distance h, must in addition be sufficient to overcome the frictional resistances within the machine itself; so the actual effort required to move the load is,

$$P s = L h + W w, \text{ or } P = \frac{L h + W w}{s} \quad \ldots\ldots(2)$$

Thus from (1) and (2) it is seen that the actual force P must be greater than the theoretical force P_1.

The ratio of the theoretical to the actual force is termed the efficiency of the machine; thus

$$e = \frac{P_1}{P}$$

As has been seen, P is always greater than P_1, and it follows that the efficiency of any machine being always less than unity, represents the percentage of the force exerted which is actually employed in moving the load. The use of this ratio expressing the efficiency is of the greatest value in practical problems relating to the force required to run any given machine; as, in the most complicated cases, the theoretical force

$$P_1 = \frac{L h}{s}$$

in which the three factors L, h, and s, are known for each particular case. Thus a knowledge of the efficiency e of the particular machine under consideration enables the designer to determine at once the force required for the particular case, as

$$e = \frac{P_1}{P}, \text{ and } P = \frac{P_1}{e}$$

The value of e for any machine is easily computed when the efficiencies of the several moving parts are known. Let e_1, e_2, e_3 ——— e_n be the efficiencies of the several moving parts of the machine; then the efficiency of the whole machine is,

$$e = e_1 \times e_2 \times e_3 \times \;-\;-\;-\; e_n \ldots\ldots\ldots\ldots(3)$$

Since the moving parts of most machinery may be reduced to a few classes or heads, a knowledge of the average values of the efficiency of each class will, in all cases, enable the designer to arrive at results sufficiently accurate for practical purposes.

In the preceding discussion it has been assumed that the force P acts in a direction to move the load forward, and that the frictional resistances act against the force P, in the same direction as the load L. The relation of power to load and frictional resistances is well illustrated in the case of a crane; and such a machine will hereafter be used in the discussion, it being understood that what is said applies as well to any class of machinery.

Efficiency of Backward Motion.

When a crane is at rest with a load L suspended, the force P is being exerted to maintain the load in suspension, and prevent it running down. In this case the frictional resistances within the machine are acting in the same direction as P, and usually the work Ww done in overcoming them is the same for the backward as for the forward motion; while L becomes the actuating force, and P acts as a retarding force to prevent acceleration when lowering the load.

Thus when the load is being lowered we have,

$$L h = P s + W w, \text{ or } P = \frac{L h - W w}{s} \quad \ldots\ldots(3)$$

while as before we have

$$P_1 = \frac{L h}{s} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

which clearly indicates that when lowering the load, the force P, which must act to prevent acceleration, is less than the theoretical force P_1. By the efficiency of a machine for the backward motion is understood the ratio of the actual force required to prevent acceleration when lowering the load, to the theoretical force required to effect the same result could the frictional resistances within the machine be neglected.

Thus for backward motion,

$$e = \frac{P}{P_1}$$

Substituting in this equation the values of P and P_1 in (3) and (4) we have,

$$e = \frac{\dfrac{L h - W w}{s}}{\dfrac{L h}{s}} = \frac{L h - W w}{L h}$$

from which we see that when $Ww = Lh$, $e = 0$, and the internal forces of frictional resistance and L are balanced without the application of P; also when Ww is greater than Lh, e has a negative value, and an additional force P acting in the same direction as L, must be applied at the point of application of the power in order to lower the load.

A negative value for e on the backward motion may therefore be taken as an indication that the load will remain suspended upon the removal of the motive power. This is a feature especially to be desired in all cranes as a safety device for those operating them. It is, however, often obtained by the sacrifice of high efficiency on the forward movement. For the forward motion we had

$$e = \frac{P_1}{P}$$

and substituting in this equation the values of P_1 and P from (1) and (2) we have,

$$e = \frac{\dfrac{L h}{s}}{\dfrac{L h + W w}{s}} = \frac{L h}{L h + W w}$$

which, under the assumption that the work done in overcoming the frictional resistances within the machine is the same for both forward and backward motion, and assuming the limiting case $Ww = Lh$, becomes

$$e = \frac{L h}{L h + L h} = \frac{1}{2}$$

Thus the efficiency for the forward motion of all elementary self-locking machines which automatically sustain the load, never exceeds 50 per cent., while for cases where n is negative the efficiency, is less than 50 per cent.

This statement is true for all elements in machine design intended to be used as power transmission elements for the forward movement, while being expected, from the nature of the design, to resist all backward impulses due to the load when the power is removed. It is possible, however, by the introduction of devices which, being idle during the forward movement, are called into action by the slightest backward movement of the parts to which they are attached, and which, being so put into action, present additional frictional resistances acting in the direction of the force P, to design a machine of any given efficiency for the forward movement, which will automatically sustain the load when the power is removed.

Rigidity of Ropes.

When considering the efficiency of the different classes of mechanism combining to form a hoisting machine, it will be seen that the resistance of ropes to bending around sheaves and drums enters largely into the equations for the efficiency of these parts. Any rope offers resistance, by reason of its rigidity, when wound onto a sheave or drum, while by reason of its elasticity, little or no resistance is offered when it unwinds and passes off the sheave or drum.

In Fig. 1 let T = the tension in the *on* side of the rope about to be wound around a sheave, and $T + T_1$ = the tension in the *off* side of the rope; then T_1 = the force required to bend the rope around the sheave while under the tension T. Let R_1 = the radius of the sheave, and d = the diameter of

the rope, while $r =$ the radius of the rope $= \dfrac{d}{2}$

Then let $R_1 + r = R$.

The lever arm of the rope axis on the *off* side is,

$$bc = R_1 + r = R.$$

Considering the *on* side of the rope, the fibers on the outside are stretched, while those on the inside are compressed, and the resultant of these two forces with the force T will lie to the outside of the rope axis—a distance denoted by h.

Then the lever arm of the *on* side is

$$ab = R_1 + e + r + h = R + e + h.$$

The distance e is given by DuBois as

$$e = \frac{k}{T}, \text{ for hemp rope and}$$

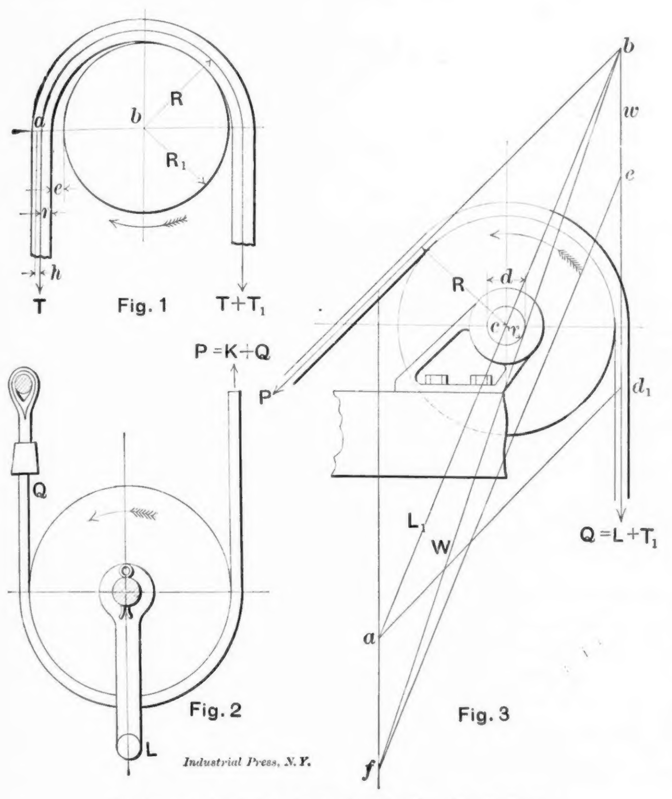
$$e = \frac{k\,R}{T} \text{ for wire ropes,}$$

where k is a constant to be determined by experiment.

The condition for equilibrium is then

$$T\left(R + \frac{k\,R}{T} + h\right) = (T + T_1)\,R, \text{ or } T_1 = k + \frac{T\,h}{R}$$

Experiment gives this formula the form,



Efficiency of Ropes and Fixed and Movable Pulleys.

$$T_1 = 1.08 + \frac{0.09\,T}{R} \text{ for wire ropes,}$$

$$T_1 = \frac{100 + 0.22\,T}{R} \text{ for tarred hemp rope,}$$

$$T_1 = \frac{4 + 0.065\,T}{R} \text{ for untarred hemp rope,}$$

where T and T_1 are expressed in pounds, and R in inches. (DuBois.)

The efficiency of the rope, neglecting the journal friction of the sheave, is

$$e = \frac{T}{T + T_1}$$

Example: A one-inch wire rope under 20,000 pounds tension is wound over a 15-inch sheave. Neglecting the journal friction of the sheave, what force $(T + T_1)$ will be required to raise the load of 20,000 pounds?

Here $T = 20{,}000$.

$R_1 = 7.5$.

$R = 8$.

then, $T_1 = 1.08 + \dfrac{0.09 \times 20{,}000}{8} = 226.08$ pounds,

and $T + T_1 = 20{,}226.08$ pounds.

The efficiency in this case is

$$e = \frac{T}{T + T_1} = \frac{20{,}000}{20{,}226.08} = .989$$

The following table, No. 1, gives the efficiency of plough steel wire ropes when strained to their full working capacity, and wound over sheaves or upon drums of the smallest diameter that should ever be used with each size of rope. It will be observed that the diameters given in this table are much smaller than those recommended by the rope manufacturers as the minimum to be used with each size of rope. The diameters given here are those in constant use by many of the foremost crane builders, it being found impracticable to use the large sheaves and drums recommended in the space at the disposal of the designers.

TABLE I. EFFICIENCY OF WIRE ROPES.

Diam. of Rope.	Min. Diam of Drum or Sheave under Rope.	Efficiency $e = \dfrac{T}{T + T_1}$
½	10	.982
⅝	12	.985
¾	14	.987
⅞	16	.989
1	18	.990
1⅛	20	.991
1¼	22	.992
	Average,	.988

The Fixed Pulley.

Let Fig. 3 represent a fixed pulley or rope sheave, over which a rope is passed, by means of which a force P is to lift a load L. The spaces s and h through which P and L move respectively are equal $(s = h)$, hence neglecting all friction and lost power, we have the theoretical force,

$$P_1 = L \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The wasteful resistances to be overcome are: 1st. The stiffness of the rope requiring the additional force T_1, which may be added to the load, making the total force acting in the *on* side of the rope

$$Q = L + T_1, \text{ and}$$

2nd. The journal friction due to the resultant pressure L_1 of P and Q, and the weight w of the sheave.

Produce P and Q to meet at b, and draw bc produced to a. Lay off to any convenient scale $bd_1 = Q$, and draw d_1a parallel to Pb. Then $ab = L_1$, and when measured to scale gives the resultant pressure on the journal due to P and Q. Lay off on bd_1 to the same scale as before, $be = w$, the weight of the sheave. Draw ef parallel to ab, and draw bf. Then $bf = W$, and when measured to scale gives the total pressure W on the journal, due to the resultant of the forces P and Q and the weight w of the sheave.

We now have three forces acting, P, Q, and W, of which Q and W are acting in the same direction, opposed to P, and as the distances through which these forces move are proportional to the lever arm in each case, we have the condition of equilibrium, letting the coefficient of journal friction $= \phi$

$$P\,R = Q\,R + W\,r\,\phi$$

$$P = \frac{Q\,R + W\,r\,\phi}{R} \ldots\ldots\ldots\ldots (2)$$

From (1) and (2) we have the efficiency

$$e = \frac{P_1}{P} = \frac{L\,R}{Q\,R + W\,r\,\phi}$$

In making calculations, we may at first neglect the stiffness of the rope, in which case $Q = L$, and we have the efficiency with the rope neglected,

$$e_1 = \frac{L\,R}{L\,R + W\,r\,\phi}$$

Let $e_2 =$ the efficiency of the rope from the table No. 1. Then we have the efficiency, including the rope,

$$e = e_1 \times e_2.$$

The maximum value of L_1 is reached when P and Q are parallel, and is then $P + Q = L_1$; the weight w of the sheave may be neglected as having little influence upon the efficiency; the rigidity of the rope may be neglected at first and brought

into the solution afterwards, as shown above; and $P + Q = 2L$. Then under these assumptions, viz., $W = L_1 = P + Q = 2L$, and $Q = L$, we have by substitution in (2)

$$P = \frac{L R + 2 L r \phi}{R} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Thus from (1) and (3) we get the minimum efficiency of a fixed sheave, neglecting the weight of the sheave, and letting the efficiency of the rope $= e_2$ as above

$$e = \frac{e_2 P_1}{P} = \frac{e_2 L}{\frac{L R + 2 L r \phi}{R}} = \frac{e_2 R}{R + d \phi}$$

The following table, No. 2, gives the minimum efficiency of the smallest diameter of sheave allowable with each size of rope, assuming in each case the load L on the rope to be the full working strength of the rope, the arc of contact to be 180 degrees, the coefficient of journal friction .08, the diameter of journal pin 4 inches, and values of e_2 taken from table No. 1.

TABLE NO. 2. EFFICIENCY OF THE FIXED SHEAVE.

Diam. of Rope.	Diam. Sheave.	e for Rope, Table I.	e for Sheave.	Coeff. of Resistance.
1/2	10	.982	.925	1.081
5/8	12	.985	.936	1.068
3/4	14	.987	.945	1.058
7/8	16.	.989	.952	1.050
1	18	.990	.957	1 045
1 1/8	20	.991	.961	1.040
1 1/4	22	.992	.965	1.036
	Average,	.988	.948	1.055

From (3) we have, including the efficiency of the rope e_2,

$$P = \left(\frac{e_2(R + d\,\phi)}{R}\right) L, \text{ and letting}$$

$$\frac{e_2\,(R + \mathrm{d}\,\phi)}{R} = k \text{ we have}$$

$$P = k\,L \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

in which k is the coefficient of resistance of the sheave and rope combined. From (1) and (4) we have,

$$e = \frac{P_1}{P} = \frac{L}{k\,L} = \frac{1}{k} \text{ and}$$

$$k = \frac{1}{e}$$

In the fifth column of the above table the values of k are calculated under the same conditions as are those of e, so that knowing either the power applied, P, or the load to be lifted, L, the other may be easily calculated with sufficient accuracy by the use of the above tabular values in the two equations

$$P = k\,L \text{ and } L = e\,P$$

For the backward motion when the load is descending, we have

$$P = k\,L$$

and

$$L = \frac{P}{k}$$

The distance through which L acts is equal to the distance through which P acts; hence letting s equal this distance, we have the work performed at the point of application of each force, P and L, as

$$P\,s, \text{ and } L\,s = \frac{P\,s}{k}$$

and the efficiency

$$e = \frac{L\,s}{P\,s} = \frac{1}{k}$$

Thus the efficiency of a fixed sheave is the same for the backward as for the forward motion.

Movable Pulley or Sheave.

In the case of movable pulleys or sheaves, Fig. 2, as in pulley blocks, the ropes are always parallel, or nearly so, and letting $Q =$ the tension produced in the *on* side of the rope by the load L, we have

$$P = kQ,$$

and the condition of equilibrium is

$$L = P + Q = Q + kQ = Q(1 + k).$$

To raise the load L a distance s, each end of the rope must be shortened by a distance equal to s, and as the end Q is fixed, this is accomplished by the end P moving upwards a distance equal to $2s$.

The energy exerted is $P \times 2s$, or

$$2kQs,$$

and the useful work performed is Ls, or

$$Qs(1 + k),$$

while the efficiency is

$$e = \frac{Q\,s\,(1 + k)}{2\,k\,Q\,s} = \frac{1 + k}{2\,k}$$

The efficiency of a fixed sheave was shown to be $e = \frac{1}{k}$, and as k is always greater than unity, we see that the efficiency of a movable pulley is greater than that of a fixed pulley.

For the reverse motion, with the load descending, we shall have the tensions in the ends of the rope reversed, and

$$Q = kP,$$

while as before,

$$L = P + Q = P + kP = P\ (1 + k).$$

The energy exerted is

$$Ls = Ps\ (1 + k),$$

while the useful work performed is

$$2ps,$$

and the efficiency is

$$e = \frac{2\,P\,s}{P\,s\,(1 + k)} = \frac{2}{1 + k}$$

for the backward movement.

The following table, No. 3, gives the minimum forward efficiency under the same conditions as for table No. 2:

TABLE NO. 3. EFFICIENCY OF THE MOVABLE PULLEY.

Diam. of Rope.	Diam. Sheave.	Coef. Resistance k.	Efficiency. $e = \frac{1 + k}{2\,k}$
1/2	10	1.081	.962
5/8	12	1.068	.968
3/4	14	1.058	.972
7/8	16	1.050	.976
1	18	1.045	.978
1 1/8	20	1.040	.980
1 1/4	22	1.036	.982
	Average,	1.055	.974

* * *

ELECTRIC FURNACE VS. BLAST FURNACE.

One of the electrical enthusiasts, to whom probably all things seem possible by the use of electricity, has endeavored to show that iron ores can be electrically smelted cheaper than they can be reduced in the ordinary blast furnace. The *Engineering News* cruelly knocks this "pipe dream" in the head—allowing such dreams have heads—in an analysis of the matter published in a recent issue. Mr. Rossi by a marvelous juggling of figures in the *Iron Age* showed that a ton of pig iron manufactured in a blast furnace, would cost \$12.47; in an electrical furnace, only \$12.15. To secure this result he charges up iron ore to the blast furnace men at the rate of \$4.50 per ton. The electrical furnace is supposed to get it for 75 cents a ton. The feature of the matter to be seriously considered, however, is the assumption that electrical energy can be furnished by water power for \$10 per year, which, of course, could not be done on a large scale except perhaps at Niagara, Sault Ste. Marie, and some undeveloped water powers in the west. But even allowing that it could be, the investment of capital would be greatly in favor of the blast furnace plant. A blast furnace having a capacity of say 350 tons per day could be erected for \$1,000,000 in round figures. An electrical water power plant capable of developing 60,000 horse power is estimated to cost probably five or six times that amount. Such a large investment would be out of the question. The conclusion is that an electric furnace can by no means compete with the blast furnace.

* * *

"Big Ben," the famous clock in the tower of the House of Parliament, London, is regularly wound by hand and it takes two men 12 hours each week to complete the operation. This is the way it is done in England, but it is not the way it would be done in America.

ENGINEERING REVIEW.

CURRENT EVENTS, TECHNICAL AND MECHANICAL—LEADING ARTICLES OF THE MONTH.

The Farmers' National Bank Building, which is to be the largest structure in Pittsburg, and one of the tallest office buildings in the world, is nearing completion and will be occupied early in March. The entire building is to be lighted with Nernst lamps, made by the Nernst Lamp Company, of Pittsburg. There are to be installed 1,000 55-watt single glower, 1,250 88-watt single glower, 20 two-glower and 20 six-glower lamps, and although different units will prevail in the building, the quality of light will be the same throughout, this being one of the features of Nernst Lamp illumination in distinction from the combination of arc and incandescent lights ordinarily found in large interiors.

A new step in the generation and distribution of power is to be taken at Pittsburg in connection with a new group of office buildings to be erected in the neighborhood of Fifth street and Duquesne Way. One plant will furnish light, heat and power for the entire group of five or six buildings, including the Bessemer building, corner Sixth street and Duquesne Way. The power equipment will include two 1,500 H. P. Westinghouse-Corliss engines, of the horizontal, cross-compound type, running non-condensing, and the exhaust steam will be used for heating purposes. On account of the high river water universally experienced in lower Pittsburg, the engines will be placed upon the ground floor instead of in the basement, while the boilers will be located on the second floor of the plant and supplemented by suitable coal and ash handling appliances.

In connection with its other projected improvements in New York and vicinity, which were already of a stupendous character, the Pennsylvania Railroad has made plans to spend about $10,000,000 additional in securing an all-rail connection with the New York, New Haven & Hartford Railroad. The plan is to build a bridge and viaduct two miles long, the bridge beginning at Port Morris, New York, and crossing to Long Island. The bridge will be built from Port Morris to Randall's Island, thence to Ward's Island, and across Hell Gate to Astoria, Long Island. The span across Hell Gate will be 840 feet long and 135 feet above high tide. The steel for the structure, weighing 61,000,000 pounds, has been ordered from the United States Steel Corporation and will cost something like $3,250,000. A line will be built from the Astoria end of the bridge to connect with the Long Island Railroad and the viaduct at the other end on Manhattan Island will complete the desired connection with the New Haven road.

The steam turbine equipment of the Hartford Electric Light Co., which was the first large installation of the kind in the country and has attracted a great deal of attention among engineers, is to be added to in the near future. The present Corliss engines will be replaced by two 1,000 H. P. turbines, direct-connected to revolving field polyphase generators. These units will operate in parallel with the 1,500 K. W. unit first installed. Superheated steam at 150 pounds pressure will be used. The original turbine at this plant has at one time or another given considerable trouble, owing, we understand, to the facts that opportunity was not afforded to completely test and adjust it at the works, and that the manager of the Hartford plant decided to increase the steam pressure after the wheel was installed, making it necessary to operate the turbine under conditions for which it was not adapted. It is significant that in spite of these difficulties the turbine has proved its worth sufficiently to warrant replacing Corliss engines with additional turbines.

There has been considerable speculation as to the effect of the "tooth of time" on the modern steel frame building popularly known as skyscrapers in New York, so the tearing down of one of these structures in this city has attracted some attention. The building in question was the Pabst Hotel, at the corner of Broadway and Forty-second street, which was erected in 1898 and which had to be torn down to make room for a larger structure to be erected by the New York Rapid Transit Railway for a station. So far as critical examination can show the framework of the building was in perfect condition, but since it had been erected only four years this evidence is not very conclusive. It does show, however, that the agencies that work for deterioration have not made progress in that space of time. The beams and girders were practically all incased in concrete. The tearing down of the frame was the reverse operation of its erection, the rivet heads being knocked off with a set-chisel and sledge and the members lowered by a derrick. All parts were carefully numbered for re-erection.

FLUE DUST BRIQUETTING TO BE TRIED.

In the *Engineering Review* of our January number was a somewhat extended account of the process for briquetting ore dust from blast furnaces. It is now announced that the Jones & Laughlin Co. will make a trial of this system which, if successful, will not only mitigate one of the worst nuisances of an iron and steel plant—the intolerable dust—but will also effect an immense saving. That the briquetted dust is of a quality suitable to use there is no question, but it remains to be proven whether the briquettes are strong enough to withstand the pressure of the ore and coke with which the furnace is charged. It is said that over 13½ per cent. of the fine Mesabi ore used by this company escapes from the blast furnaces in the form of dust, and this is said to mean a loss of over $350,000 a year. It is estimated that if the briquetting system were also used in the oil regions there would be a saving of over $1,000,000 annually on the total shipments of ore, from the fact that as now transported freight must be paid on an immense weight of water with which the ore is saturated. This water would be eliminated in the briquetting process, and, as previously stated, the estimated saving would be $1,000,000, or very much more than would be necessary to cover the expense of briquetting.

MORE ABOUT THE PROPERTIES OF NICKEL STEEL.

Nickel steel alloys in varying proportions have many strange properties. We have already mentioned the very small coefficient of expansion possessed by nickel-steel containing about 36 per cent. nickel, being something like one-thirteenth that of wrought iron. An article by M. Paillot in the Journal of the *Société Industrielle du Nord de la France*, states that the magnetic properties are quite as interesting. An alloy of 25 per cent. nickel with steel, is not magnetic at ordinary temperatures, although its components are strongly so, but when subjected to a very low temperature it becomes magnetic and preserves this state when brought back to the normal temperature. Alloys which generally contain less than 25 per cent. nickel contents, are strongly magnetic under certain conditions, but lose their magnetic property when heated to cherry red and only resume it when cooled to a very low temperature. An alloy containing slightly more than 25 per cent. nickel, is only magnetic at temperatures below the freezing point of water. Some alloys diminish in density by about 2 per cent. by passing into the magnetic state. Again wires made of steel containing 24 per cent. nickel resemble soft brass wires when in the non-magnetic state, but in the magnetic state they become springy as though made of hardened steel.

ELECTRICALLY-EQUIPPED HOUSES.

It is said that the electrical equipment of the reconstructed White House is the most complete to be found in all the country. Elaborate arrangements are provided for lighting the house and grounds effectively during receptions or other state functions, and there are numerous electrical appliances for use in the kitchen, for operating the elevator automatically without the need of an attendant, and for other purposes.

There are two telephone systems—one for the use of the President and his family, and the other for State uses.

While this installation is on a large scale, it is doubtful whether it is more complete than that in the somewhat famous house of Chas. R. Barnes, the New York State electrician, at Rochester, N. Y. Mr. Barnes has made this equipment his hobby, without regard to expense, and he has even gone to the extravagance of heating his house by electricity. The heaters are controlled from a single switchboard in the library, and a unique feature that must appeal to any lazy man is that the heat may be turned on without the sleeper having to venture from the protection of the warm coverlets.

In the kitchen are electric cooking devices—including an oven for baking—and less necessary but very desirable arrangements, such as electric chafing dishes and what is called an electro-therm, which is a flexible pad heated by electricity and used like a hot-water bottle. The lighting system is very complete, there are electric fans in every room, and last Christmas a tree was decorated with 600 incandescent lamps. This electrical installation may possibly be the forerunner of what is in store for the most humble householder a few years hence.

NEW PRESIDENT OF STEVENS INSTITUTE.

On February 5th, Mr. Alexander C. Humphreys was inaugurated as president of Stevens Institute of Technology, Hoboken, N. J. The ceremonies consisted of exercises with addresses by leading educators and other prominent men, with a reception in Carnegie laboratory, Stevens Institute, and an alumni dinner at Sherry's, New York. The new president, in his address, outlined his views of technical education, contending that the competent engineer should not only be trained in mathematics, mechanics, physics, etc., but in certain broadening subjects such as English, logic, history, modern languages, economics, and business methods. Upon the latter he laid especial stress, and said, "It is not enough that the technically trained engineer should be practical in the shop and in the field; he must be practical in his ability to meet business men on their own ground. Some engineers fail to secure success because they carry too large a proportion of science; some because they have not enough, and others because they fail to recognize that commercial efficiency must outweigh theoretical efficiency. The training of the engineer must be a harmonious blend of science, practice, and commercial judgment."

Mr. Humphreys has long been identified with Stevens Institute as a member of the Trustees and was practically the unanimous choice of trustees, faculty, students and alumni for the office of president. He was born in 1851 in Scotland and when he came to this country began life in the insurance business and later was connected with the Bayonne and Greenville Gaslight Co., Bayonne, N. J., finally becoming their general superintendent. At this time he was desirous of securing a technical education and made arrangements to take lectures at Stevens Institute in connection with his regular duties at Bayonne. He distinguished himself in his studies in spite of the restricted time that could be devoted to the course of study, and graduated with such honors that a special vote of commendation was passed by the faculty of the institute—an unprecedented recognition. Mr. Humphreys has devoted his life to the engineering of gas plants and for several years held the position of superintendent of the United Gas Improvement Co. of Philadelphia. Ultimately he was connected with the sales and other commercial departments of the business, giving special attention to the development of the water-gas branch of the business, of which he made a specialty. In 1894 he resigned from this company and established the firm of Humphreys & Glasgow, consulting engineers, London, with offices also in New York, making a specialty of water gas. Mr. Humphreys at one time or another has been the chief executive of over 50 gas and electric companies and in all his work has been distinguished by rare executive ability.

A DUST-PROOF BUILDING.

There is one building in Pittsburg from which smoke and soot are excluded and whose occupants do not have to wonder whether their lungs are slowly becoming carbonized. It is perhaps the only smokeless and dustless spot in the city. This building, according to the Pittsburg *Leader*, is the one containing the offices of the Pittsburg & Lake Erie Railroad. The windows and doors are made to fit as tightly as possible, the former even being packed with felt to exclude the dust, and the whole interior of the structure is supplied with pure air by an elaborate ventilating system which maintains a pressure in the building slightly in excess of atmospheric pressure. The air enters through an intake on the roof and passes directly to the basement, where it goes through a chamber fitted with hot water heaters used in winter to partially warm the air and prevent freezing of the apparatus. From this it passes through a washer or spray room in which is a system of water jets for precipitating the dust in the air, and it finally passes by a series of baffles or sheet iron plates, which are intended to catch the surplus moisture in the air. The air is again heated and driven through ducts into the various offices by a large fan, which fan also serves to draw the air down the intake from the roof. A second series of baffles has also been installed to reduce the humidity of the air as much as possible and their application seems to be reasonably successful, since we are informed that even in summer weather the air is not moist enough to be uncomfortable. The air enters the rooms through grated openings in the ceiling, to which deflectors are applied to dissipate the current. Other grated openings near the floor connect with a duct leading to a suction fan on the roof. It is evident that circulating a large quantity of air in the condition in which it is found in Pittsburg would ordinarily result in coating everything with black soot in a short time, but it is said that papers or books left standing for weeks in this building remain clean and show no indication of the smoke that is so annoying everywhere else in the city.

In other respects also the building is modern, as for example in the supply of ice water, which is delivered to all parts of the building by a pipe system. The water is distilled by an independent plant, and is kept circulating in the pipes, so that it is not necessary to let the water run before using.

ELECTRICAL VS. COAL CAR TRANSMISSION.

The *Electrical World and Engineer* discusses editorially the electrical transmission of energy vs. coal car transmission. In Colorado the comparison between these two methods has been more actively considered than in any other locality. The cost of hauling coal in a level country by modern railroad methods seems to be so low that the cost of a transmission line with the fixed charges thereon will wipe out any advantage to be gained from using the coal directly at the mines and transmitting the power. In the mountains of Western Colorado, however, there are cases where there is no question as to the economy of transmitting at high voltage rather than hauling fuel to the station from some inaccessible mine. In the Cripple Creek district conditions are such as almost to balance the two methods. In this latter district can be found power transmitted 26 miles at high voltage from a plant located near the coal mines, and also power supplied from a plant in the district. In this case the country is mountainous. But that there is little difference between the cost of power when transmitted and the cost when generated in the district, is shown by the fact that engineers of national reputation have been responsible for the building of both types of plants. Farther east in Colorado, at Denver and Colorado Springs, where the country is comparatively level, nearly every large generating plant that has been built during the past few years, has been erected only after a careful consideration of the ultimate cost of power from a plant located at the coal mines as compared with a plant located in the city. Coal is found near both Colorado Springs and Denver. So far, however, only one plant has been built at any considerable distance from a city for the purpose of getting its coal at the mines.

But the cost of coal transportation is not the only thing to be considered in this connection. Skilled labor of the kind necessary to operate a large generating plant, can be ob-

tained at the mines only at a much higher rate than if the plant were located in more congenial surroundings. Mining communities are likely to be lonely places for a man who is skilled in power house operation; and if the right kind of men are to be kept there, they must be paid for staying. Furthermore, it is frequently figured that if the station is located at the mine, it is for the purpose of utilizing the slack and coal dust that would not be shipped because of its low grade. If this kind of fuel is used, it requires a large boiler capacity per kilowatt, because in practical operation there is always the possibility that a poor streak of fuel will get into the furnace about the time the heaviest load comes on. To provide for such emergencies, the boiler capacity provided must be larger than would otherwise be necessary. Hence, in view of these considerations, it is safe to assume that in a level country the high-voltage transmission line as a competitor of a railroad cannot show a saving.

THE MODERN BATTLESHIP.

World's Work. February, 1903.

An English writer has recently described a battleship as the "last word that mechanical genius, naval construction and cash payment can say in aggressiveness." From the fighting-top to double bottom, from ram to sternpost, she is the most complicated machine the mind of man ever conceived. There is scarcely a trade or an art that is not represented in her building. She is a house that must be lighted, ventilated, drained, and painted. She is a fort that must carry guns of heaviest calibers for fighting other battleships; guns of medium size for piercing the comparatively thin protection of armored cruisers; scores of rapid-firers for protecting herself against torpedo boats, and even a battery of small Colts for picking off sharpshooters and exposed men. Above all, she is also a ship to be taken to sea, to make passages from port to port and long ocean voyages. Moreover, she is a hostelry in which there are 700 men who must be clothed, fed and housed, and for whose use there is provided an ice plant having a capacity of three tons of ice per day and evaporators that daily produce 16,000 gallons of fresh water; there is also a bakery and an enormous kitchen for cooking. Besides the ponderous main engines of say 16,000 horse power there are perhaps nearly one hundred auxiliary engines or about the same number of electric motors. The boilers, with their 46,000 square feet of heating surface, must not be forgotten, nor the coal bunkers, which, in the Oregon, for instance, have a capacity sufficient to steam that vessel a distance of 5,500 miles without recoaling.

NEW METHOD OF TESTING WIRE.

Abstract from Paper read by Arthur Falkenau before the Engineers' Club, November, 1902.

In a paper read before the Engineers' Club of Philadelphia by Arthur Falkenau, November 1, 1902, a new method and machine for testing wire were described. The author says that plow steel wire rope, is or should be the best for any purpose. The term "plow steel" refers to wire having a tensile

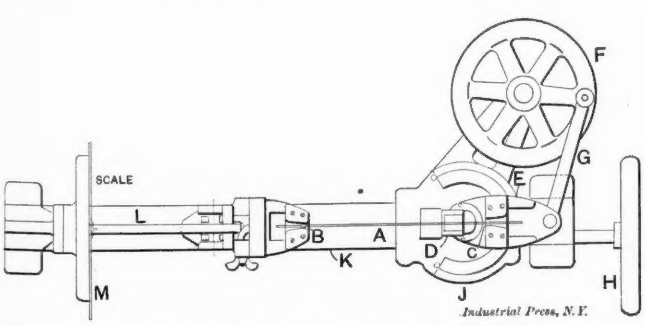


Fig. 1. Plan of Machine for Testing Wire.

strength of 200,000 pounds per square inch and even higher. The wire for ropes for all sizes from 2½ inches diameter to the smallest, should be uniformly graded in strength from 200,000 to 275,000 pounds per square inch approximately. But it does not follow that wire of this high strength will necessarily show a reduced number of bends received in testing; on the contrary if the wire is made from good quality of stock and properly treated the number of bends should be increased. The ability to resist bending stresses, is, of course, the principal limiting factor in the life of wire ropes, as the most serious wear comes from the constant bending around sheave wheels or drums. Wire must be selected that will stand the greatest number of bends through an angle of not less than 90 degrees under a load uniformly proportionate to the ultimate strength of each test specimen. Of course this load must be below the elastic limit. If this plan is followed it is not necessary to consider either the torsional or elongation test, simply because wire rope is not subject to either of these strains when installed.

The machine for making the bending tests is shown in diagram by Fig. 1. The specimen of wire, *A*, is introduced into the grips *B* and *C* and passed between the hardened steel blocks at *D*. For a tensile test, turn the handwheel *H*, which screws the head *J* out along the bed *K*, producing a tensile stress in the wire which is transmitted through the lever *L* to the scale *M*, which is shown on edge. The bending test is made by applying the desired initial load by means of the handwheel *H*, then rotating the handwheel *F*, which swings the arm *E* by means of the connecting-rod *G* and bends the wire about the hardened steel blocks at *D*.

This machine has shown that the old method of bending test, is unreliable. By the old method, low carbon steel or double-worked refined iron even may be made to show more bends than the best plow steel. But if the test is made under the same conditions, subjecting each specimen to a load of, say, one-fourth its ultimate strength, as can be readily done in this machine, the plow steel will at once show its superiority for rope.

THE COOPER-HEWITT ELECTRIC MERCURY LAMP, AND STATIONARY CONVERTER.

Engineering (London), January 16, 1903, p. 82.

The remarkable mercury vapor lamps devised by Mr. Peter Cooper-Hewitt are now being exhibited at the offices of the Westinghouse Company, Norfolk street, Strand. These lamps can be run off any ordinary continuous-current electric light supply system, and show an efficiency of 3.3 candles per watt, (5 candles per watt is 100 per cent. efficiency), or for the same lighting require only about one-ninth the current taken by ordinary incandescent. The sole drawback to the light lies in its extraordinary color. There is a total absence of all red rays, and consequently all tints red by ordinary light are curiously perverted. A lady's lips look purple; so that at present no attempt is being made to utilize the light for domestic purposes, as feminine opposition would be too strong. In other cases, however, the light has very great advantages. It is stated that it is an excellent light to work by, and this we can well believe. The light comes from a tube about 1 inch in diameter and about 3 feet long, and this tube is filled with a continuous glow from end to end. No portion of it has the painful brightness of a glow-lamp filament, and it is possible without discomfort, to gaze directly at a tube yielding a light of 700 candle-power. The light-giving vapor being so voluminous, there are no sharp shadows; a fact which is of great importance in the lighting of warehouses and factories. The light is, moreover, highly actinic, and can be used advantageously for printing ordinary photographs or blue prints.

The lamp consists of an exhausted glass tube having a bulb at one end. This bulb contains a little liquid mercury in which is immersed a platinum electrode, which passes through the glass, and is connected to the negative terminal of the supply system. At the other end of the tube is a second platinum wire, which is coupled up to the positive main, and inside the glass has attached onto it a fragment of iron which forms the positive electrode. The bulb at the other end of the tube is covered externally with a conductive coating, which is connected up to the positive side of the supply. This coating and the mercury inside the bulb constitute, therefore, a small condenser which is of use in starting the lamp. Once the lamp is started, it is sufficient to maintain a difference of 85 volts between the terminals. The whole tube is then filled with mercury vapor which has a temperature of between 3,600 degrees and 5,400 degrees F. This vapor is continually condensing on the cold walls of the containing glass, whence

it finds its way back into the bulb, to be evaporated afresh. The amount in the state of vapor at any time is, however, extremely small, and consequently the glass does not get really hot, nor is the light obstructed by the portion condensed on the interior surface of the tube. A much higher potential is required to start the lamp than to run it. This starting potential is obtained very simply by means of a compound switch. This switch has two circuit-closers, one of which opens and closes the main circuit through the lamp, while the other throws in or out of circuit a coil of large self-induction, arranged in parallel with the lamp. In starting, the switch for the lamp circuit is first closed; but, owing to the high resistance of the lamp, no current flows. The second switch is then moved round; this first closes the circuit through the induction coil, and then breaks it. The spark on discharge has no path open to it, save through the lamp. It accordingly goes that way, breaking down its resistance, and the current can then be maintained through the lamp by a potential of only some 85 volts. The action of the induction coil is reinforced by the condenser formed between the mercury and the outer coating of the lamp bulb, as above described. Two or more lamps can be run in series. The sizes made range from 16 candle-power up to 10,000. The former has a tube 3 inches long by 1/8 inch in diameter and the latter a tube 12 feet long by 3 inches in diameter. The voltage can be adjusted within wide limits, since the resistance of the column of mercury vapor varies directly with its length and inversely with its diameter. The latter point is curious, and may, perhaps, be due to the column of vapor being hollow.

The lamps are used only on continuous-current circuits, since a current can pass through them in one direction only. This fact has been applied to the production of a rectifier for altering currents now being developed by the Westinghouse Company, the device being known as the "Hewitt static converter." In this arrangement a vacuum tube or bulb containing only mercury vapor is fitted with a positive electrode for each phase of an alternating current, but has a single negative electrode only. As the current can pass in one direction only, a unidirectional current is obtained. Converters on this plan may be used for all voltages between 100 and 1,000 volts, and for all capacities up to 100 amperes. The efficiency is very high, the sole loss being the constant drop of 14 volts in the bulb. Hence with a 100-volt system the efficiency is 86 per cent., but with a 1,000-volt supply it is 98.6 per cent. The apparatus is cheap, and requires no more attention than an ordinary transformer.

THE CONDITIONS NECESSARY FOR SUCCESSFUL COAL DUST BURNING.

Abstract from Paper read before the Indiana Engineering Society by F. A. W. Davis.

On account of the following advantages possessed by coal-dust fuel as enumerated by Mr. Davis, vice-president of the Indianapolis Water Company, that concern installed a plant costing some $25,000 for the purpose of manufacturing coal-dust fuel for their power plant:

1. Cleanliness of the boiler room.
2. Use of coal screenings (much of which now goes to waste).
3. Perfect combustion of 80 per cent. of the coal.
4. Reduction of the cost of coal for fuel, and the number of employees to handle it.
5. Ready facilities for increasing the heat quickly, consequently the capacity of a boiler plant. (To many concerns this is important.)
6. Lessening the quantity of coal wasted with the ashes.
7. Lessening the quantity of ashes to be handled.
8. Smoke prevention, a most desirable condition anywhere.

The machinery installed by the water company for producing powdered coal has a capacity of 140 tons in twenty-four hours, and is as follows:

1. Cylindrical rotary drier through which all the slack coal is passed. The moisture must be taken out of all coal before it goes to the grinding machinery, otherwise it is impossible to grind it to the satisfactory degree of fineness.

2. Rotary ball mill into which the coal is delivered from the drier. This is a drum 5 feet 6 inches diameter, and 3 feet 6 inches long inside, revolving at 22 revolutions per minute. This drum is partially filled with steel balls, which reduce the coal to 8 mesh, that is, so it will pass through a screen of 8 meshes to one inch.

3. The rotary tube mill which receives the coal from the rotary ball mill. This mill is a cylinder 4 feet diameter inside and 20 feet long, lined with buhrstones, such as used in flouring mill work, and is filled about one-half full of pebbles brought from Greenland (none being found in this country that will do the work). The cylinder revolves at the rate of about 25 revolutions per minute, and it reduces the coal to about 100 mesh. The tube mill requires 60 horse power to drive it; the ball mill, 18 horse power; and the drier, 8 horse power.

Mr. Davis thinks, as the result of the knowledge and experience gained with this plant, that one of the secrets of successful coal-dust burning is in grinding the coal almost as fine as flour, so that it will be consumed while suspended in the blast. This means that part of the ashes will be unavoidably carried into the tubes and there cause loss of heat unless means are provided for their removal. He concludes that the chief difficulties to be overcome in successful coal-dust burning, are:

1. Grinding the coal to the proper degree of fineness.
2. Regulating the quantity of dust required to produce the heat; also the quantity of air and its pressure to burn it.
3. The proper construction of the furnace.

HYDRAULIC FORGING PRESS.

Zeitschrift fur Werkzengmachinen und Werkzenge. December 5, 1902. p. 99.

A forging press whose construction is shown in the accompanying engraving has been recently built by Haniel & Lueg at Dusseldorf, Germany. The press itself consists of a simple hydraulic cylinder, with a steam cylinder placed above it as the source of power, and is attached to the press itself by means of steel connections *B*. The piston rod that runs down from the steam piston forms the ram for the cylinder *D* of the press. By means of the difference in the diameters of the steam pistons and this plunger a pressure of about 6,000 pounds per square inch is exerted by the head *E* of the press upon the material to be worked. The development of the hydraulic pressure and its transference to the ram head of the machine take place in the same chamber. There are, therefore, neither the valves nor the piping that are usually found where high pressures are to be used.

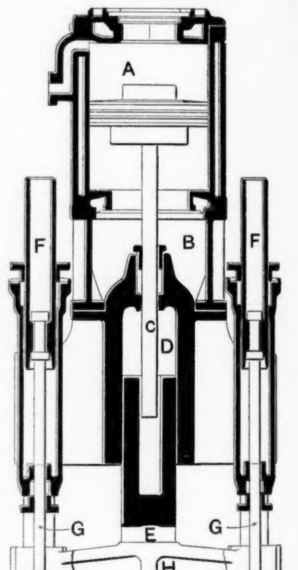


Fig. 2. Hydraulic Forging Press.

The lifting of the head, after accomplishing its work, is effected by means of two pistons *FF*, which are under constant pressure of about 750 pounds and whose piston rods *GG* take hold of the four corners of the head of the press. As soon as the steam pistons are relieved of the pressure upon them the withdrawing cylinders lift the head and draw it back to its uppermost position.

The speed of this press is dependent upon the speed with which steam can be admitted to and exhausted from the upper cylinder, and this can be done at the rate of from thirty to forty times a minute.—G. L. F.

THE CUTTING ANGLES OF TOOLS.

Abstract from Paper read before the Institution of Mechanical Engineers by H. F. Donaldson, January 16, 1903.

The author gave an account of tests made under his direction at Woolwich to determine the best angles for lathe tools made of the new high-speed, self-hardening steels. He first laid down the conditions that, what a tool will do depends upon: 1. The material of which it is made. 2. The nature of the material to be worked. 3. The speed it is to work at. 4. The depth of cut. 5. The width of feed. A diagram was introduced in the paper, Fig. 3, to make clear what he meant by the cutting and clearance angles of tools. The top and side pressures on the tool were determined by a simple apparatus mounted on the tool-holder by means of which the pressure was transmitted hydraulically to ordinary pressure gages. The tool was balanced on a knife edge and the factor of leverage multiplied by the indicated pressure gave the actual pressure.

In one test in which the pressure on the tool was determined for different depths of cut, a pointed tool like that shown in the diagram, Fig. 3, was used, having a front cutting angle of 60 degrees; front clearance, 5 degrees; side cutting, 60 degrees; side clearance, 5 degrees; and horizontal angle, 40 degrees. In this trial medium hard steel at a speed of 14.65 feet per minute, feed 1-32 inch, depth of cut 0.1 inch, developed a pressure of 81.25 pounds on top of the tool. With the same speed, but a feed of 1-20 inch and a depth of cut of 0.125, the pressure increased to double or 162.5 pounds, being directly proportional to the cross-section of the cut in this case.

TABLE I.—SHOWING BEST RESULTS IN OPERATING ANGLES OF TOOLS.

Material, Index No., and Degree of Hardness.	Diameter.		Speed of Material.		Speed of Tool.			Tools and Angles.						Lubricant Used.	State of Tool-edge after Work.			Shavings.		Surface of Specimen After Work		
	Before.	After.	Revolutions per minute.	Feet per minute.	Feed.	Travel.	Time.	Nature of Tool.	Front Cutting.	Side Cutting.	Front Clearance.	Side Clearance.	Horizontal.		Not Damaged.	Slightly Damaged.	Completely Damaged	Long.	Short.	Smooth.	Rough.	Very Rough.
	ins.	ins.			in.	ins.	mins	inch.	deg.	deg.	deg.	deg.	deg.									
I. Steel HHH.	3.4	3.2	18	15	$\frac{1}{40}$	3	6.75	1 C S.	75	69	2	2	33	Soda Hyd.	..	Yes	..	..	Yes	Good	..	..
II. Steel H.	1.85	1.7	70	32	$\frac{1}{70}$	6	6	"	59	$62\frac{1}{2}$	3	3	33	"	..	Yes	..	Yes	..	"	..	..
III. Steel HHN.	5.75	4.95	18	27	$\frac{1}{60}$	3	9	"	$62\frac{1}{2}$	$62\frac{1}{2}$	1	1	32	Do. and Soap.	..	Rough on Edge	..	..	Yes	"	..	..
IV. C. Steel HH.	6	5.15	18	25	$\frac{1}{40}$	1	2.25	"	65	63	$2\frac{1}{2}$	1	42	"	..	"	..	Long	..	"	..	..
V. Steel HH.	1.5	1.25	70	$27\frac{1}{2}$	$\frac{1}{61}$	1	0.44	"	$62\frac{1}{2}$	$62\frac{1}{2}$	3	3	42	"	Not	...	..	Yes	..	"	..	..
VI. Steel H.	8.35	7.5	$5\frac{1}{2}$	12	$\frac{1}{8}$	10	15	$1\frac{1}{4}$ M	55	52	4	5	35	"	Not	...	..	Yes	..	"	..	..
VII. Steel HO.	6.75	6.25	$5\frac{1}{2}$	10	$\frac{1}{14}$	18	44	"	$57\frac{1}{2}$	55	8	8	40	"	Not	...	..	Yes	..	"	..	..
VIII. W. Iron M.	3	2.75	70	55	$\frac{1}{70}$	2	2	1 C.S.	$57\frac{1}{2}$	55	3	3	42	"	Not	...	..	Yes	..	"	..	..
IX. C. Iron	4.95	4.3	18	21	$\frac{1}{27}$	2	3	"	60	64	$1\frac{1}{4}$	1	35	Nil	..	Yes	..	..	Yes	"	..	..
X. G.M.F.	3.37	3	140	122	0.02	4	1.45	"	61	64	3	0	35	Soda	Not	...	..	Yes	..	"	..	..
HH.	3	2.7	320	251	0.03	6	0.6	"	61	64	3	0	35	Hyd.	Not	...	..	Yes	..	"	..	..
XI. G. Metal M.	2.6	2.37	320	217	0.03	6	0.6	"	73	74	2	5	35	"	Not	...	..	..	Yes	"	..	..
XII. G. Metal S.	3.5	3.25	320	293	0.03	5	0.5	"	73	74	2	5	35	Nil	No	...	..	..	Yes	"	..	..
XIII. G. Metal F. HH.	2.65	2.45	224	160	0.02	4	0.75	"	78	78	1	0	35	Soda Hyd.	Not	...	..	..	Yes	"	..	..
XIV. G. Metal F. H.	2.4	2.125	224	140	0.02	3	0.55	"	$62\frac{1}{2}$	64	3	3	35	"	Not	...	...	Yes	..	"	..	..

Very hard material indicated HHH. Medium hard material indicated HH. Hard material indicated H.
Oil-hardened material indicated O. Medium material indicated M. Soft material indicated S.
Forged material indicated F. Nickel Material indicated N.

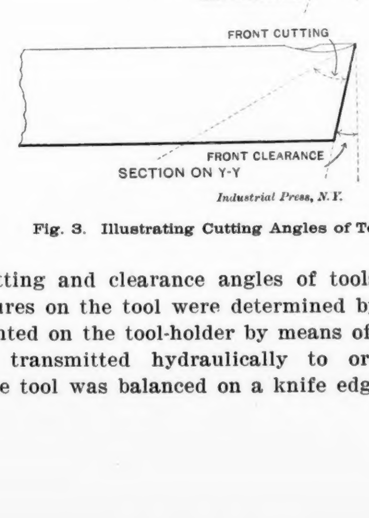


Fig. 3. Illustrating Cutting Angles of Tools.

TABLE II. LIMITS OF CUTTING ANGLES.

	Front Cutting.	Side Cutting.	Front Clearance.	Side Clearance.	Horizontal.
	deg.	deg.	deg.	deg	deg.
For cutting mild steel..	52 to 60	50 to 60	3 to 8	3 to 8	33 to 43
For cutting medium steel	54 to 63	60 to 65	3 to 8	3 to 8	33 to 43
For cutting hard steel..	65 to 78	60 to 70	3 to 8	3 to 8	33 to 43
For cutting soft yellow metal...............	62 to 74	62 to 74	3 to 8	3 to 8	33 to 38
For cutting medium yellow metal...........	62 to 74	70 to 75	3 to 8	3 to 8	33 to 38
For cutting hard yellow metal...............	60 to 80	60 to 80	3 to 8	3 to 8	33 to 38

While the author found that a sharp-pointed tool gave the least resistances, he admits, of course, that in actual work the rounded nose tool is the best. It is stronger, and having more metal takes the heat slower, and gets rid of it quicker. He condemns spring tools, laying great stress on the necessity for absolute stiffness and rigidity in the tool and its support. In all the tests the top of the tool was set slightly above the center of the work, the amount varying, of course, with the diameter. He finds that the ruling factor in fixing cutting angles, must in all cases depend, to a large extent, upon the

hardness of the metal to be worked; the harder the metal the more obtuse the angle. In Table I are tabulated the best results in operating angles of lathe tools. The lubricant was not flooded on, but was only dropped in small quantities.

In Table II the author gives what he considers to be limits of cutting angles. The discussion following the reading of the paper indicated a keen interest in the subject, and the criticism was of a very intelligent character. The full paper and discussion may be found in *Engineering*, date January 23, to which we are indebted.

THE YEARLY COST OF ONE STEAM HORSE POWER.

Engineer, February 2, 1903. p. 145.

Wm. O. Webber says that there is misunderstanding in regard to the cost of steam horse power. While it is true that the cost per horse power in the larger plants developing 1,000 to 1,500 horse power may be from $22 to $26 per year, it is by no means true that these figures hold for smaller plants. Mr. Webber has had occasion in the last few years to make up the figures on the cost of a number of small power plants. From these figures he has made up the accompanying table:

which would be a close check on the 400 horse power plant, where surely a condensing engine would be used. De Courcey May gives the corresponding figures as $33, which is considered to be too low for so small an engine as 400 horse power, though approximately correct for an engine as large as 700 or 800 horse power. On the larger engines, which would be either triple expansion, or compounds with a ratio of expansion corresponding to a triple, the figures of $23 for a 1,500 horse power engine check very closely.

Some little time ago, Mr. Webber averaged the figures of a number of estimates made by several different authorities, with the following results, 100 horse power, $63; 200 horse power, $45; 300 horse power, $37; 400 horse power, $32; 500 horse power, $29; 600 horse power, $28; 700 horse power, $27; 800 horse power, $26; 900 horse power, $25; 1,000 horse power, $24; 1,500 horse power, $22; 2,000 horse power, $21.

These figures he believes to be correct for the larger horse powers, but are too low for the smaller powers, principally because these have been based on mill plants, where better types of engines prevail, and more attention is given to economical administration.

COST OF ONE HORSE-POWER PER ANNUM.

Ten-hour basis, 308 days per annum.

Size of plant, H. P.	100	200	300	400	500	600	700	800	900	1,000	1,500	2,000
Cost of plant, per H. P.	$170.00	$146.00	$126.00	$110.00	$96 00	$85.00	$76.00	$69 00	$64.00	$60.00	$58.00	$56.00
Fixed Charges at 14%	$23.80	$24.40	$17 65	$15.40	$13.45	$11.90	$10.65	$9.65	$8.95	$8.40	$8.12	$7.85
Coal per H. P. H., pounds	7.0	6.5	6.0	5.5	5.0	4.5	4.0	3.5	3.0	2.5	2.0	1.5
Cost of fuel at $4 per ton	$38.50	$35.70	$33.00	$32.00	$27.50	$24.70	$22.00	$19.20	$16.50	$13.75	$11.00	$8.25
Attendance 10-hour basis	12.00	10.00	8.60	7.25	6.20	5.40	4.70	4.15	3.75	3.50	3.25	3.00
Oil, waste, supplies	2.40	2.00	1.72	1.45	1.24	1.08	0.94	0.83	0.75	0.70	0.65	0.60
Total, coal $4.00 per ton	76.70	68.10	60.97	56.10	48 39	43.08	38.29	33.83	29.95	26.35	23.02	19.70
With coal at $5.00 per ton	86.40	77.10	69.22	61.90	55.29	49.28	43.79	39.73	34.05	29.80	25.77	21.75
With coal at $4.50 per ton	81.50	72 60	65.07	58.10	51.79	46.18	41.04	36 28	32.00	28.05	24.39	20.72
With coal at $4 00 per ton	76.70	68.10	60.97	56.10	48.39	43.08	38.09	33.83	29.95	26.35	23.02	19.70
With coal at $3.50 per ton	71.90	63.70	56.82	50.50	45.04	39.98	35.54	31.48	27.87	24.60	21.64	18.67
With coal at $3 00 per ton	67.00	59.20	51.67	46.70	41.49	36.88	32.79	29.03	25.80	22.90	20.27	17.65
With coal at $2.50 per ton	62.30	54.75	48.59	43.00	38.83	33.83	30.04	27.18	23.75	21.20	18 89	16.60
With coal at $2.00 per ton	57.45	50.25	44.47	40.10	34.64	30.73	27.29	24.23	21.70	19.47	17.52	15.57

In this table it will be seen that, while a 1,000 horse power installation of boilers, engines, buildings, chimney, and all accessories, costs about $60 a horse power, the same installation for 300 horse power costs at least double per horse power. It has been found by these figures that the interest on the first charges should be 14 per cent., of which interest is 6 per cent., depreciation 4 per cent., repairs 2 per cent., insurance 1 per cent., and taxes 1 per cent. It will also be noted in this table that, while for a 1,000 horse power installation the coal necessary per horse power per hour for the main engine, pumps, condensers, etc., is only 2½ pounds, on a small plant of 300 horse power at least 6 pounds of coal must be allowed for these same purposes. The cost of fuel is given at $4 per ton, that being considered a fair average price, delivered on the fire room floor.

The attendance varies very largely with the size of the plant. In a 1,000 horse power plant, three men in the boiler room during the day at $1.50 a day, and one night man at $1.50 would be only $1.85 per horse power. One engineer at $3 per day and an assistant at $2 per day would only be $1.54 per horse power. However, $3.50 is allowed for attendants, instead of $3.39, which this would amount to. On the other hand, in a 100 horse power plant an engineer at $2.50 a day would be $7.72 per horse power, and a fireman at $1.50 a day would be $4.62 a horse power, amounting to a little over $12. In this case the amount is called $12, and the attendance for the other amounts of power is proportioned in a ratio which would apply to the different sizes of powers and numbers of attendants required.

The cost of oil, waste, and supplies is also similarly proportioned, and the results check very closely with those found in average practice; also the figures given by such authority as Dr. Charles E. Emery, of New York, who makes the cost of a horse power with a simple low speed non-condensing engine, with coal at $4 a ton, about $76. De Courcey May gives a corresponding figure of $57, but this is known to be too low. Dr. Emery gives the cost of a horse power in a low speed condensing engine, with coal at $4 a ton, about $56,

A WATER WHEEL FLOW RECORDER.

Abstract of Paper read before the meeting of the A. S. M. E., January 26, 1903, by Prof. C. M. Allen.

The recorder is designed for use where water power is sold by large companies to individual users, as at Holyoke and Lowell, Mass. In order to apply the machine the wheel for which it is to register must be tested so that the flow at various gate openings and heads is known. A curve is then plotted between gate opening with gate openings as vertical ordinates, and head as horizontal, and this diagram—wrapped around a cylinder—is used as one boundary of a toothed surface, the other of which is the vertical axis of gate openings. At the bottom of the cylinder this toothed surface will come to a point, and at the top will nearly surround the cylinder, as seen at *a*. The grooved surface meshes with a small gear at the side of the cylinder, seen at *b*.

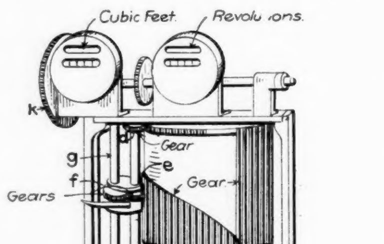


Fig. 4. Register for Flow of Water.

This gear turns the shaft *c* by means of a feather, and the shaft, in turn, by means of the gear *d* at the top, rotates the upper drum.

On the upper drum the curve bounding the toothed surface

is plotted between flow and head, hence is a square root curve; and this surface engages an idler gear e on the shaft c, which meshes with a gear f, driving the shaft g by a feather.

The shaft g moves the register wheels by means of bevel gears, as in the ordinary water meter.

The lower drum is driven by a screw gear on the shaft h, which is belted to the water wheel shaft.

The vertical position of gear b is controlled by a sprocket chain and wheel k, and varies with the gate opening, the lowest position corresponding to closed gate, and the highest to full gate. The gears e and f, on the same carriage, are controlled by the head acting on the wheel, being at the bottom of the drum when the head is greatest.

The revolution counter is connected by sprocket and shaft to shaft h and records the revolutions of the turbine.

The lower cylinder, in one revolution turns the gear b a number of revolutions proportional to its distance from the bottom, hence proportional to the gate opening, and the upper cylinder, which is driven by b, also turns in proportion to the gate opening. The upper cylinder, in one revolution turns the gear e a number of revolutions proportional to its distance from the top, hence depending on the head. The record is therefore varied as the head and the gate opening vary.

If so desired, the curve of the upper cylinder may be plotted proportional to the $\frac{3}{2}$ power of the head, in which case the register will read in power developed instead of flow.

Recorders have been in use for about two years, giving entire satisfaction, and have shown on careful test against a Venturi meter and a standard weir a maximum error of 3 per cent. and a minimum of less than 1 per cent.—A. L. R.

LARGE STEAM TURBINE INSTALLATION.

Steam Engineering, February, 1903, p. 252.

The Massachusetts Electric Companies, controlling about 900 miles of street railways, have contracted with the General Electric Company for ten 3,000 horse power and three 1,000 horse power steam turbines of the Curtis vertical type direct-connected to electric generators, making an aggregate of 33,000 horse power. Mr. C. F. Bancroft, chief engineer of the Massachusetts Electric Companies, states that the ten 3,000 horse power turbines will be installed in three stations superseding thirteen of the engine-driven stations now operated by the companies. At present the lines south of Boston, comprising about 380 miles of track and designated as the Old Colony Division, are operated from eleven separate stations, distributed irregularly over the territory served. Nine of these will be displaced by two steam turbine central stations, one aggregating 9,000 horse power, located at Fall River, and one of 12,000 horse power capacity at Quincy Point. The lines north of Boston, known as the Boston & Northern Division, comprise about 455 miles of electric railway track, and are now operated from ten separate power stations. Five of these power houses will be displaced by one steam turbine station, aggregating 9,000 horse power, located at Danvers, Mass. The three 1,000 horse power steam turbines mentioned are intended for a small combined lighting and electric railway power house at Newport, R. I., which is also under the control of the Massachusetts Electric Companies.

The steam turbines, which, as stated, are of the Curtis vertical type, will run at the very low speed of 750 revolutions per minute, taking steam at 175 pounds pressure at the turbine nozzle. In each unit the generator is mounted on the upper end of the turbine shaft without the interposition of reducing gears of any kind. Alternating current of 13,000 volts, three-phase and 25 cycles per second, will be generated. Each of the larger turbines will be 12 feet diameter at the base, 19 feet high and will weigh approximately 190,000 pounds.

The Newport station plans provide for four 1,000 horse power Curtis vertical turbines, of which three are now being installed. The boiler room is to be fitted with equipment for supplying superheated steam on the Schmidt system, which may be used or not at will, the intention being to carefully experiment and note the action of the turbines with both saturated and superheated steam. Four 350 horse power Aultman & Taylor water-tube boilers, fitted with Green economizers, will be installed at first. The separately-fired superheater stands at one end of the line of boilers, and the arrangement of the steam piping is such that steam can be taken through the superheater or direct from the boilers.

The annexed elevation, Fig. 5, shows one of these 1,000 horse power turbines and gives the principal dimensions. It will be noted that the engine room floor level is above the

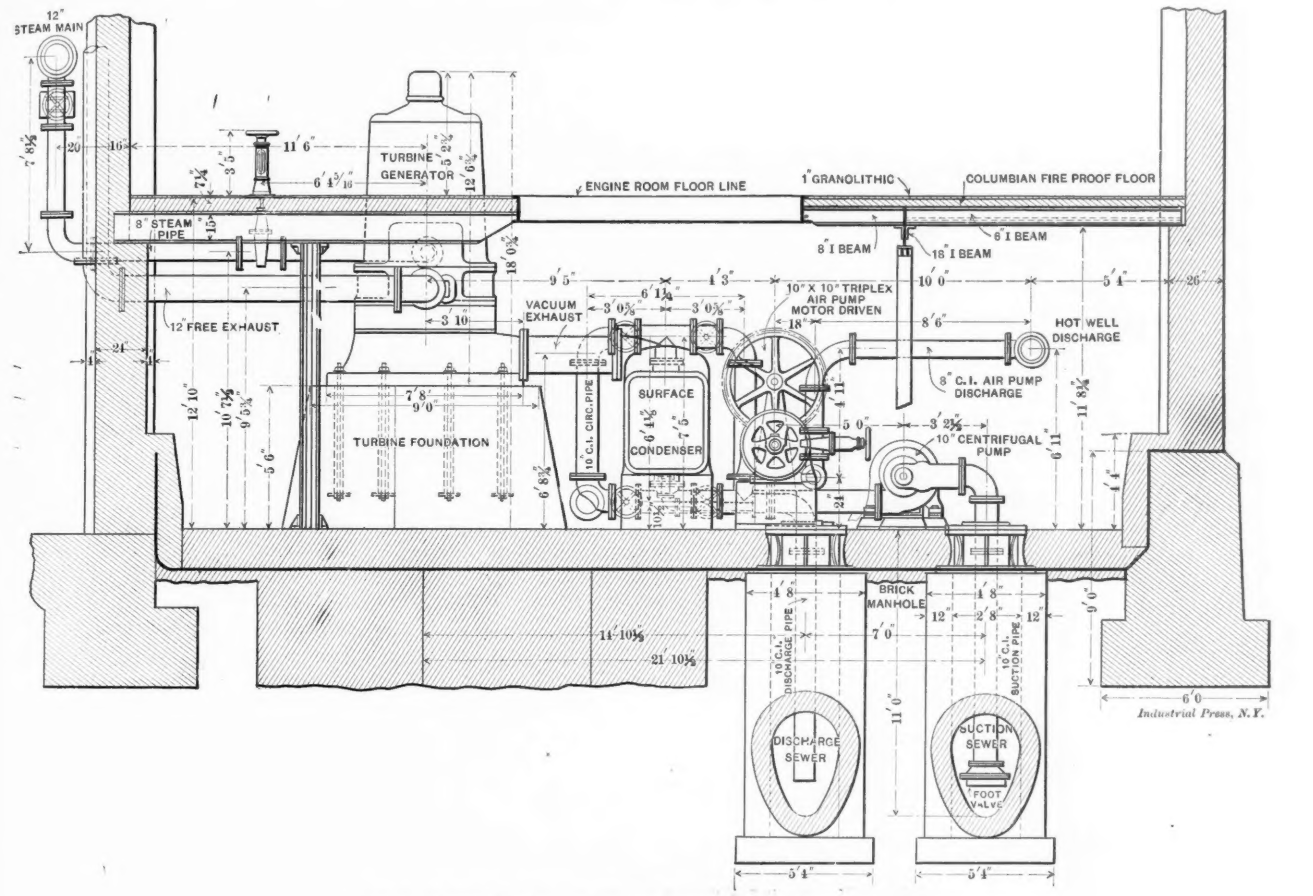


Fig. 5. Elevation of Steam Turbine Installation at Newport, R. I.

turbine proper, the generator only being above it. These generators are 500 kilowatt, 2,500-volt machines, built by the General Electric Company and run at the turbine speed, which is 1,800 turns per minute. The turbines are 7 feet 8 inches diameter at the base and 12 feet 6¾ inches high from the bottom of the bedplate to the top of the governor cap. A heavy foundation of brick is provided for each unit, the dimensions being 9 feet square at the top, 11 feet at the bottom and 5½ feet high. Beneath this is an 18-inch bed of concrete.

* * *

A NEW MOTOR DRIVEN LATHE

WITH VARIABLE SPEED MECHANISM.

Since the introduction of electric power for driving lathes and other machine tools, many designs have been made for adapting the motor to the tool. The first method employed was to run a countershaft from the motor and then drive the tool from this countershaft in the usual manner. Then builders began making provision for the motor as a part of the tool; yet even at the present date, in many of the electrically operated tools the motor has a decidedly "stuck on" appearance. The Flather Co., Inc., Nashua, N. H., have just brought out an electrically operated lathe which provides for incorporating the motor as a part of the tool in a very novel manner, as well as doing away with belts, chains or similar devices.

The photograph, Fig. 1, illustrates their 14-inch engine lathe, which has been equipped in this manner, and Fig. 2 shows a detail of the motor connections and driving mechanism. The motor is placed in a box leg, and while in the present case it is shown on the right hand side of the leg, it can be placed at the left equally as well. When placed as shown in the photograph a plate is cast in the bed to protect the motor from all chips and dirt. The body of the motor is held firmly in place by means of lugs fastened to it and in turn screwed to the leg, while the inner end fits into a hole bored in the cross ties cast in the leg.

On the end of the armature shaft is a rawhide pinion, *A*, meshing with metal bevel gears *B-B*, turning them in opposite directions. These gears are keyed to the frictions, *C-C*, and are connected or disconnected by the lever *D*. This lever, which starts, stops and reverses the lathe, runs the full length of the bed and is convenient at all times to the operator. On the upper end of shaft *E* are keyed five metal flanged rawhide gears of different diameters, which mesh with five corresponding gears running loosely on shaft *H*. These gears are connected to shaft *H*, one only at a time, by means of a key, *I*, which slides in a keyway cut in the shaft. When the key *I* is moved from gear to gear by means of lever, *J*, it is depressed flush with the shaft by the collars placed between the gears *G-G*. By this means the key must be entirely out of one gear before the springs placed under the key can force it into the keyway in another gear; hence there is absolutely no way by which more than one gear at a time can be connected to the shaft *H*. On the upper end of shaft *H* is a bevel gear *L* meshing with a similar gear on the lathe spindle where the cone is usually placed. Back gears are operated in the usual manner. The lever *J* is very convenient for the operator and can be moved while the lathe is running, giving a quick change of feed instantly, with practically no shock or jar. The motor can be removed for inspection without disturbing any other part.

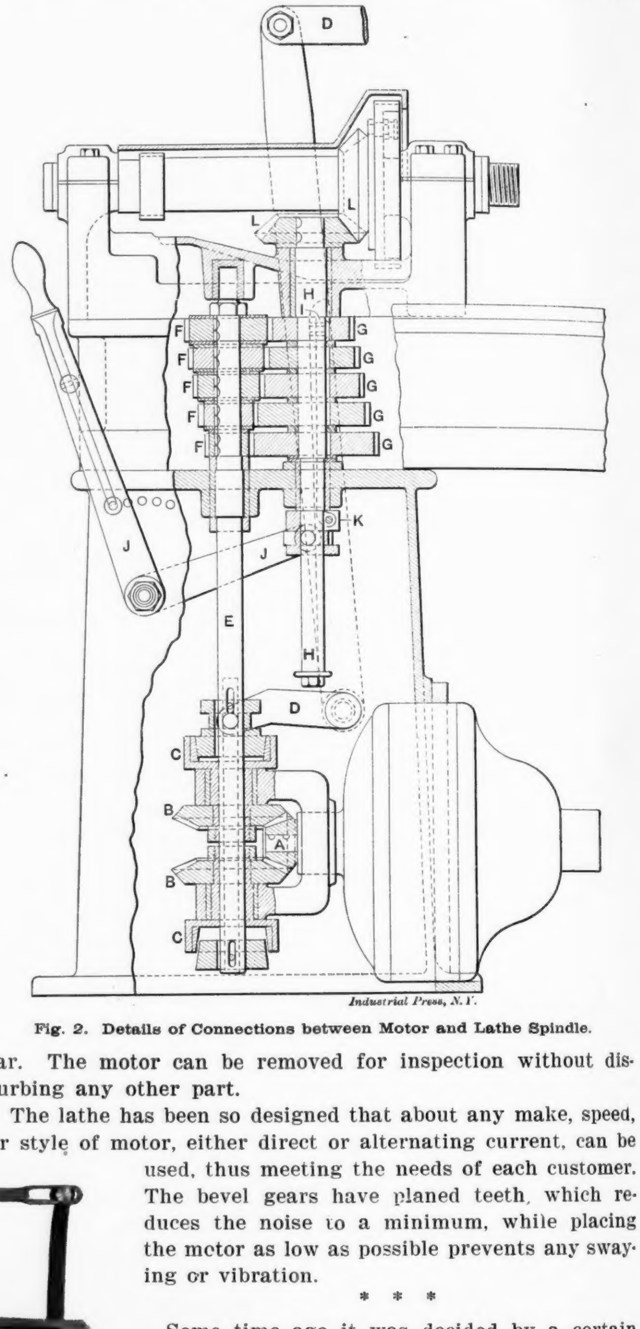


Fig. 2. Details of Connections between Motor and Lathe Spindle.

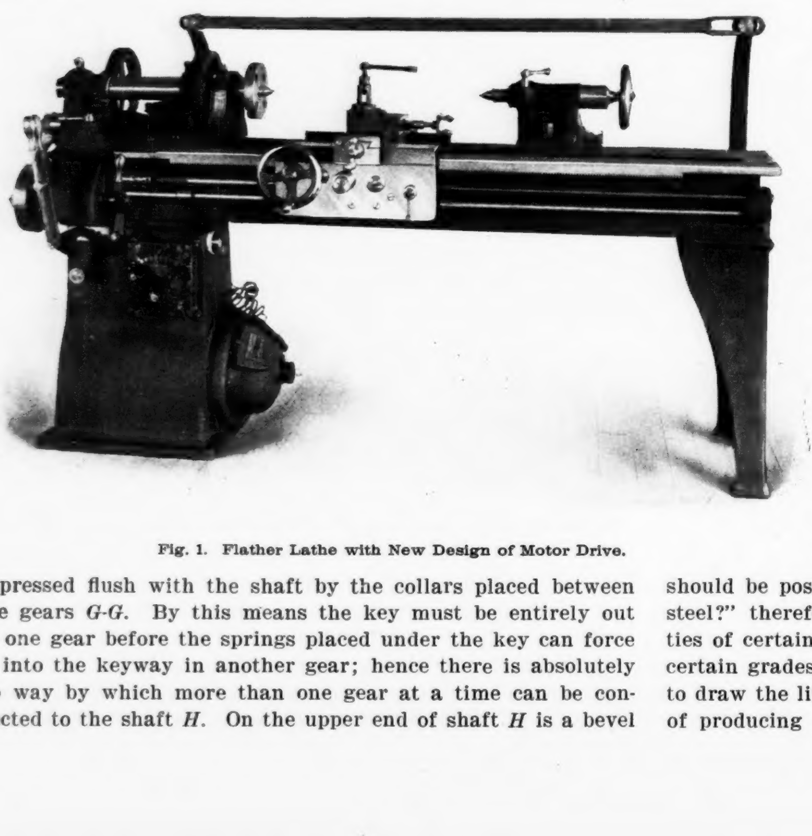


Fig. 1. Flather Lathe with New Design of Motor Drive.

The lathe has been so designed that about any make, speed, or style of motor, either direct or alternating current, can be used, thus meeting the needs of each customer. The bevel gears have planed teeth, which reduces the noise to a minimum, while placing the motor as low as possible prevents any swaying or vibration.

* * *

Some time ago it was decided by a certain magistrate in Sheffield, Eng., that some utensils made of a malleable iron to which 25 per cent. of boiler punchings had been added, might be regarded as steel instead of iron. An analysis of the mixture showed the composition to be substantially the same as that of steel. While it could not be denied that the mixture was different from steel, and in reality malleable iron, yet no chemical or microscopic test showed wherein it differed. Prof. J. O. Arnold, of the University College, undertook to find out what a logical definition of steel would be. He was finally obliged to resort to a definition based upon the process used in making the material rather than to a definition of the characteristics that should be possessed by the material. The question "What is steel?" therefore, still requires a direct answer. The qualities of certain grades of steel border so closely upon those of certain grades of iron that it seems impossible to know where to draw the line other than to give a description of the means of producing the metal.

STEEL AND ITS TREATMENT.—7.

ANSWERS TO INQUIRIES.

E. R. MARKHAM.

The writer is pleased to note a growing interest in the subject of hardening steel, and should this be due in any measure to the series of articles on this subject published in MACHINERY he will feel amply repaid for the part he has taken. As so many letters have been received from readers who were desirous of learning some point not brought out in the articles, it has seemed wise to answer them in the form of an article, rather than to answer the letters personally. In the latter case only the party receiving the letter would be benefited, while if published in the form of an open letter, or article, some who have not made inquiries as to the cause of troubles they were experiencing will be enlightened also.

In the first place, to become a successful hardener one must be somewhat familiar with the nature of steel. This knowledge may be gained by a study of books written on this subject, but while there are many works devoted to this subject there are few that would be of any special benefit to the average mechanic. The writer would, however, recommend Metcalf's work entitled "Steel, A Manual For Steel Users," in which the subject is presented in a clear, concise manner, and can readily be understood by any man of ordinary intelligence. The composition and nature of steel is treated of in a way that will benefit any careful student of the book.

Another work which the writer found of much value when studying the subject was written by an English authority—W. Matthieu Williams.

Letter No. 1 informs me that the writer had a number of long tools to harden, and becoming greatly interested in the heating of steel in red hot lead, he decided that this would furnish an ideal method of heating the tools. Results were anything but satisfactory, the steel was brittle, the tools did not stand up well, one part was apparently not as strong as another, and in fact he didn't believe (upon trial) that red hot lead furnished as satisfactory a means of heating steel as one might imply from reading articles on the subject. When the hardened steel was broken the grain was coarse, and withal he "was very much dissatisfied with results obtained."

Now, in answer to the foregoing, would say, that probably no one method so universally used in heating steel is the cause of as much annoyance as red hot lead—because *certain points* are not observed. While an impure lead may lead to unsatisfactory results, so far as the surface of steel is concerned—and for this reason *chemically pure* lead should always be used—yet an open grain is the result of high heats. In other words, the amount of heat a piece of steel receives rather than the method of applying it, affects the *grain*. Then again lead is not as hot on the surface as lower down in the crucible, and consequently when long pieces are heated the portion of the steel near the bottom of the crucible is apt to be much hotter than that nearer the top, unless the lead is stirred occasionally to equalize the heat. This undoubtedly accounts for the difference in the amount of brittleness in various parts of the piece.

Unfortunately very little attention is paid in most shops to the location of any apparatus used in heating or making steel. If after installing the machinery there is a place left in the shop that apparently can never be used for any other purpose, the furnace used for heating steel is placed there. Many times the location is directly in front of a window or where some strong light will shine in it, or in the workman's eyes; and, as a consequence, the heats cannot be observed as they should be, and steel is overheated. To obtain satisfactory results the furnace must be so located that the heats can be readily observed by the operator, or the articles will be overheated. Lead furnishes a very satisfactory method of heating small pieces of work, if care is observed in selecting the lead and in the amount of heat given.

Letter No. 2 contains the following complaint: "When hardening milling machine cutters, of the form shown in enclosed sketch (Fig. 1), the steel cracks at the root of the tooth. A cutter with 20 teeth will sometimes come out of the bath with only 9 or 10 teeth that are not cracked, and in many cases the teeth will have been broken off entirely, and will be found in the bottom of the tank. We are using what is recommended to us as the best steel for the purpose. Can you recommend a good steel for the above-mentioned tools, one that will not crack when it is hardened?"

I am very loath to say anything about a make of steel for any given purpose; because, in the first place, it is evident that the fault is not altogether, if at all, in the steel used, but rather in the manner in which it is used. Almost any of the *leading* brands of steel on the market give good results if properly treated, and *none* of them act satisfactorily unless properly treated. And in many cases the steels that give best results if handled properly, require more careful treatment than some steels that will not do as much work when hardened. It must be borne in mind that steel is given a higher percentage of carbon than formerly so that tools may run at higher rates of speed, and cut harder stock than formerly. The higher the percentage of carbon the more care it must receive when being heated.

When steel is heated it is expanded to a considerable degree, and when plunged in the cooling bath the process of contraction takes place. Now, as the teeth are slender, they chill, and consequently are hardened much more quickly than the more solid portion between the bottoms of the teeth and the hole. Being hardened they are unyielding and cannot conform to the contraction of the balance of the piece, which continues for some time; and the result is that the heavier portion is reduced in size and shape, and the teeth, being inflexible, cannot conform to the change. Consequently the steel is torn apart at the point where the two portions—teeth and body—join.

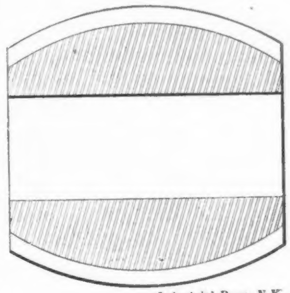


Fig. 1. Section through the Milling Cutter.

If the process of annealing is resorted to after the mill is blocked out to shape—or somewhere near to shape—the tendency to crack is reduced; this was explained in our article on annealing.

Uneven heats are many times a source of trouble when steel is hardened, as then the steel is contracted more unevenly than would otherwise be the case. Some hardeners get excellent results by dipping the cutter in a bath of water or brine having one or two inches of oil on its surface; the cutter is passed down through the oil into the water, which should be warmed somewhat.

In the article in the January number an excellent method is described, namely, dipping in water or brine until the teeth are hardened, then removing and plunging into oil and leaving until cold.

When it has not been possible, or has not seemed advisable for some reason, to anneal the blank after it was blocked out somewhere near to shape, it may be heated, when it is ready for hardening, to a red and allowed to cool off, and then reheated and hardened. This has the effect in a measure of reducing the tendency to crack from internal strains. Never use *cold* baths for hardening articles of the description mentioned; warm baths give fully as good results and are not nearly so apt to cause the steel to crack. This tendency to crack will be reduced if the angular milling cutter used in cutting the teeth is slightly rounded on the points of its teeth; sharp corners are always an invitation for steel to crack when hardened.

The hardener should bear in mind the fact that the lower the heat given a piece of steel when hardening—provided it is hot enough to produce the desired result—the less brittle the steel will be, and the less liable to break from the effects of contraction. And again if steel is brittle it is necessary to reduce the brittleness by drawing the temper to a degree that makes it softer than it should be. Knowing this the hardener will endeavor *never* to overheat or heat unevenly a piece of steel, especially when it is of a form that betokens trouble.

Letter No. 3 reads: "I am called upon to harden a great many springs, which are made mostly of sheet steel, punched and bent to shape. Formerly the springs were made of a good quality of tool sheet steel, and we had very satisfactory

results when they were hardened in lard oil, and the temper drawn by 'flashing' the oil. This was accomplished by placing the springs in a long-handled pan, moving the pan back and forth over a fire until the oil on the springs caught fire and burned. But our people were convinced that a cheaper steel would answer the purpose as well, and so bought some made especially for springs. This apparently hardens all right, but if the oil is 'flashed' off of it the springs are too soft." The people who sold the steel state that others are having excellent results using this steel for springs similar to the ones we are making. Is the trouble with me or with the steel?"

In answer to this would say that, not having tested the steel I do not know as to its adaptability for the job in hand. Many times steel is sold to the consumer by a local dealer who knows no more about the metal than a sailor does about preaching. It is advisable when ordering steel for such purposes as the one mentioned to consult the makers, telling them exactly what is expected of the article. Any of the reliable steel concerns, when they know what is wanted of a steel, will furnish the desired quality, together with necessary instructions as to treatment. However, as the steel used, apparently hardened all right it was, in all probability, not high enough in carbon to allow of drawing it as low as the tool sheet steel. Now in order to find the proper temperature it would be necessary to experiment somewhat. A few springs could be placed in a kettle of oil provided with a thermometer and whose contents were heated to 550 degrees, and the springs could be tested. If this temperature left them too hard, one could heat somewhat hotter, and this experiment could be continued until they show the proper amount of elasticity. An excellent spring can be made from steel not high enough in carbon to stand up when oil or tallow is flashed off of it, if it is heated to the proper degree when tempering.

Letter No. 4 conveys the information that the writer has never done very much hardening, but has read every book and mechanical journal containing information pertaining to hardening steel, and consequently considers himself well qualified to take charge of such work. In fact he has succeeded in securing a position as foreman of a hardening plant, but certain things have arisen that require expert judgment on matters that are not considered in any of the books or articles he has read. Now it is a fact—unfortunately—that manufacturers consider it necessary to make certain articles of a form, and from stock that must be treated somewhat differently from the ordinary methods. Right here the practical, experienced hardener finds the information he has derived from the study of books and technical papers valuable; for, while the work in hand may be different from anything he has experienced or read about, if he understands the nature and peculiarities of steel, he will be able to devise a way of doing the work. Experience is a very valuable and necessary qualification for a man if he is to become a successful hardener of steel, but that alone will not qualify him to successfully meet new propositions.

The study of steel, and of methods of manipulating it is intensely interesting and very necessary but taken alone it does not qualify one to become a hardener of steel, much less to take charge of a department doing this class of work. For matters are constantly coming up that require a certain "judgment" that can only be acquired by experience. In no branch of shop work is a man in charge required to rely more on the fruits of his past experience than in the hardening department. If in addition to this experience he has a thorough knowledge of the metal he is working, he is an invaluable man.

In the past the subject of steel and its treatment has been given very little consideration, but now that manufacturers are paying more attention to it the temptation is very strong for some men who have given the subject a little study and who in addition to this are blessed—or cursed—with too much self-confidence, to represent themselves as thoroughly competent to assume responsibilities. This can but end disastrously to themselves and to the concern employing them, and it must also reflect on the cause which the writer and others are trying to elevate, namely, the "Study of Steel and Its Treatment." The only advice we can give the writer of letter No. 4 is to give up his position before it is taken from him, and to get a job in a hardening plant doing a variety of work, becoming familiar with the work in hand. Then the value of his study will be apparent. But let him keep right ahead with his studies; he will never be too old to learn, or if he does get too old to learn, he can take it for granted he is too old to continue in this line of business.

Letter No. 5 informs me that a party is having trouble hardening cylindrical pieces; soft spots are constantly bothering him. It may be a little consolation for him to know that he is not the only hardener who has been troubled with soft spots when hardening work of a cylindrical form, especially such pieces as have surfaces perfectly plain; that is, without teeth or other irregularities. But as the knowledge that other people have similar troubles is of little practical value, we will consider a method—or rather some methods—of doing away with this trouble.

A very common error in the making of articles other than cutting tools is to use steel just large enough to clean out when machined. As a consequence the decarbonized portion referred to in a previous article is not removed entirely, and the result is soft or spotty surfaces. Then again, if the piece is heated in a manner that exposes it to the action of the air, or to the fire, the surface is liable to become oxidized, and the scale of oxide raises in the form of blisters, holding the contents of the bath away from the steel. Thus it cannot come in contact with the steel, and therefore it cannot absorb the heat at this point rapidly enough to cause the steel to harden. This tendency to oxidation may be overcome by placing the article in a tube or some receptacle which will prevent its contact with the air or fire. Better results will follow if the articles are packed in a box or tube with some carbonizing material, the receptacle being sealed with fire clay to keep the air from entering and the gases from escaping. When the steel has reached a uniform low red heat remove the pieces and dip in brine. If the material for making the article is tool steel, the carbonizing element used may be charred leather. If, however, it is high carbon steel, better results will follow if a mixture of hoofs and horns is used in place of charred leather especially if the steel is to be exposed to the action of the carbonaceous material for any length of time after it is red hot. An excellent plan is to place a quantity of chemically pure cyanide of potassium in an iron dish or crucible, heat it to a low red, suspend the article in it until it has reached a uniform low red heat, when it may be removed and immersed in a bath of brine or a solution of cyanide of potassium and water.

My object in answering these questions through the columns of MACHINERY is that I think, with the exception of one, that they are representative of troubles that may have been experienced by quite a number of readers.

* * *

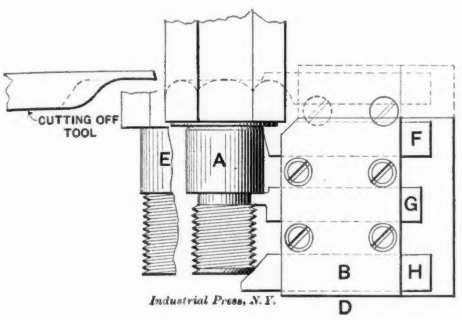
Molybdenum is a metal which, until recently, has been but little known outside of the laboratory, and its name even now is strange to the general public. Of late years, however, it has been much inquired for. It has been found superior to nickel for hardening and toughening steel. It is even better than tungsten for that purpose. Nickel makes steel tough; tungsten makes it tough and hard; but tungsten steel is disposed to crack under impact. Molybdenum makes the steel both tough and hard and does not make it brittle. It has the additional quality of keeping the steel cool. It is, therefore, valuable in the manufacture of quick-firing guns. Molybdenum is one of the most refractory of metals. It cannot be melted in any furnace, nor even under the blowpipe. Nothing but the electric current will reduce it to a liquid state. A current of about 50 volts and 900 to 950 amperes will melt it. The ore resembles lead, and is mostly found in laminæ and thin wedge-shaped masses in quartz veins. It is generally composed of about 60 per cent. of pure molybdenum and 40 per cent. of sulphur. The greater part of the ore supply has hitherto come from Sweden; but small quantities have been obtained from Maine and Arizona. Recently it was discovered in the county of Hastings, Ontario. At the present time molybdenum ore, carrying 60 per cent. of the metal, is worth about 400 dollars per ton, and the pure molybdenum about 2 dollars a pound.—*Iron and Steel Trades Journal.*

LETTERS UPON PRACTICAL SUBJECTS.

CUTTING OFF BOLTS AND CHAMFERING THE HEADS.

Editor MACHINERY:

I have had several occasions to use the style of forming tool described by Mr. Hayes under "Screw Machine Tools for Making Bolts" in the January issue, but have found it impossible to get a finished head on bolts or studs by chamfering with the side of the cutting-off tool, for the reason that when the tool begins to chamfer, it puts a side strain on the bolt and causes it to break off when the center of the stock is reduced to about ⅛-inch diameter. This leaves a rough spot and a burr extending from the center to the edge.



Bolt Forming Tools.

I have shown in dotted lines on the cut clipped from the letter by Mr. Hayes, the chamfering tool placed at the back and the cutting-off tool cut back, as also shown by dotted lines, to relieve the side strain and allow the bolt to remain until it drops off by its own weight. F. C. ARRY.

Chicago, Ill.

FAVORS A NEW SYSTEM OF MEASUREMENT.

Editor MACHINERY:

I have read with great interest the arguments pro and con the metric system and it seems to me that each party in the argument is too firmly fixed in its opinion to yield to the other side. There is, however, a system which might conciliate both sides, and it is one that has already received some attention. I mean the duodecimal system which, to my mind, is the only natural and hence the rational system of numeration.

Some say that because we have ten fingers it is quite logical that the numeration should go by ten, since at first men computed upon their fingers as upon an abacus given by Nature. Well, I claim that we possess the duodecimal system as well as the decimal, if not better, as will be seen by referring

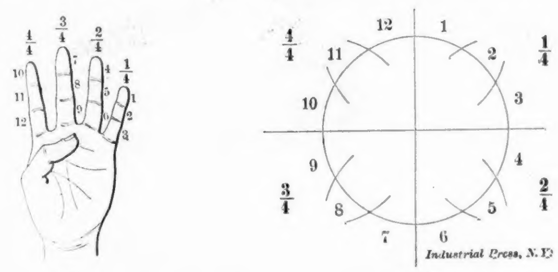


Fig. 1. Fig. 2.

Illustrating the Natural System of Numeration.

to Fig. 1. It shows the left hand in which one can count up to 12 upon the finger joints, using the thumb as an index or pointer, and this requires the use of but one hand, leaving the other free for figuring. To count ten upon the fingers requires the use of both hands. A more striking proof that this is the natural system is found in the circle. Is it not naturally and geometrically divided into 12 parts? On a circle (Fig. 2) lay off two diameters making right angles with each other and from each intersection with the circle strike arcs, equal to the radius, cutting the circumference two by two and you will obtain exactly 12 equal divisions. Why then divide the circle into four "quadrants" of 100 "grades" each, as is now done by the topographical and hydrographical surveys of the French Government? Four hundred has never divided the circle logically while 360, being a multiple of the hexagon and duodecagon, is the natural division.

Coming now to the practical side of the question, I have something to propose in lieu of the meter and the foot, and a "natural" measure, too, which is as universal and "non-national" as is the second for computing time all over the world. The proposed standard measure should be the length of the pendulum that beats seconds at the equator line and at the sea level. Such a length is subject to no contestation whatever. Whether measured in inches, in millimeters or otherwise it is still the same. Some will raise the objection that all the existing machinery would have to be changed, as also the measuring instruments, but practically it will cause no greater change than the one necessitated by the adoption of the metric measures. The duodecimal system and a new standard, natural and logical, is, I think, the best solution to give to a problem so difficult to solve only because of nationalities, for, besides having the advantages of the two others it possesses none of their disadvantages.

EDW. C. CHODZKO.

Haiphong, Tonkin, China.

SPIRAL GEARS AGAIN.

Editor MACHINERY:

The subject of spiral gearing seems to be a very vague one to some people, and if anything is written in this article that will be of any help or use to anyone, or supply some missing link, so that the subject may appear more clearly, then some good will have been done. The particular cause of this being written is the desire of a certain party to make a pair of gears such that, the axes being at right angles, the pitch diameters, and consequently the outside diameters, should be

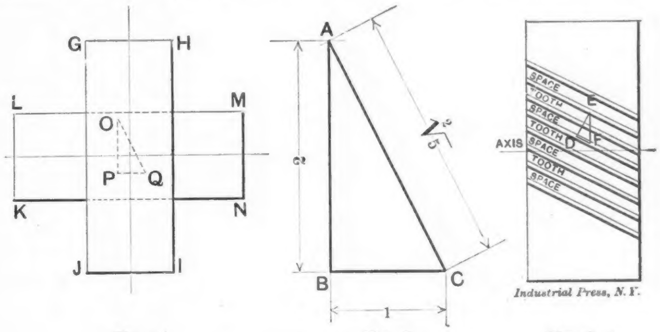


Fig. 1. Fig. 2. Fig. 3.

Spiral Gears.

equal, but the ratio should be 1 to 2. For the purpose of illustration it does not make any difference what number of teeth or pitch the gears were actually made, as the rule will apply in one case as well as another. We will take a gear (preferably the driven) of 40 teeth and a pinion (or driver) of 20 teeth.

Referring to Fig. 1, let *G H I J* represent a gear blank which we will place over another gear blank *K L M N* of equal size. Then it must be evident that if we are to cut twice as many teeth in the one as we do in the other the circular pitch, or the distance from one tooth center to the next, measured on the pitch circumference at right angles to axis, will be twice as great on the first as on the second.

Lay out a right angle triangle such that the line *B C*, Fig. 2, will be 20 units long, or say equal to 1 to represent the pinion, and the line *A B*, 40 units long, or equal to 2 to represent the gear. Then if we consider the line *A B* to be the axis of the gear, the line *A C* will be the direction of the line of the teeth, and angle *B A C* will be the angle which the gear must be moved so that the cutter may properly form the teeth.

Likewise if we consider *B C* the axis of the pinion then angle *A C B* will be the angle of the teeth. Or stating the same thing in a different form, the acute angle adjacent to the line representing the pinion in a right angle triangle is the angle of the teeth of the pinion. And the corollary to

this, the acute angle adjacent the line of the gear is the angle of the teeth of the gear.

To prove that this is correct, we will solve our triangle as constructed and find angle $B\ A\ C$ equal to 26 degrees 34 minutes, and angle $A\ C\ B$ equal to 63 degrees 26 minutes. Then if our gear is to have 40 teeth and cut with an 8 diametral pitch cutter the normal circular pitch ($D\ E$, Fig. 3) is .39269 which corresponds to the circular pitch of spur gears. But the circular pitch of a spiral gear is measured on the pitch circle but at right angles to the axis or on line $E\ F$, Fig. 3, and not on the line $D\,E$. Angle $D\,E\,F$ on our gear is 26 degrees 34 minutes, and side $D\ E$ is equal to .39269, therefore $E\ F$ is equal to .39269 times the secant of angle 26 degrees 34 minutes, or .39269 times 1.11803 is equal to .43903, which gives us the distance of the spiral circular pitch. This, times the number of teeth, which is 40, gives us 17.5616 inch as the pitch circumference.

Taking the pinion in the same manner, the angle of the teeth equals 63 degrees 26 minutes, also angle $D\ E\ F$ is the same. Therefore, $D\ E$, which is the .39269 as before, times the secant of 63 degrees 26 minutes will give the spiral circular pitch; or $.39269 \times 2.23607 = .87808$. This, times the number of teeth in the pinion (20) equals 17.5616. This result shows that the pitch circumferences of the pinion and the gear are the same, consequently the pitch diameters are equal.

The above may be reduced to a formula and the operations shortened considerably.

Let $D\ P$ equal diametral pitch of cutter used.
N equal number of teeth wanted.
$P\ C$ equal pitch circumference.
$P\ D$ equal pitch diameter.

$$\text{Then } \frac{\pi}{D\,P} \times \text{sec. of angle} \times N = P\,C \quad (1)$$

$$\frac{P\,C}{\pi} = P\,D \text{ or } P\,C = \pi \times P\,D$$

Substitute this in (1) and cancel π from both sides of equation.

$$\frac{1}{D\,P} \times \text{sec. of angle} \times N = P\,D$$

$$P\,D = \frac{\text{sec. of angle}}{D\,P} \times N$$

Thus, the secant of the angle of the teeth divided by the diametral pitch of the cutter and that result multiplied by the number of teeth in the spiral gear will be the pitch diameter of the gear. Therefore in our pinion of 20 teeth if we take the secant of 63 degrees 34 minutes and follow our rule we shall have 2.23607 divided by $8 = .27951$. This, times the number of teeth $(20) = 5.5902$ as the pitch diameter.

This method considerably shortens the operations and renders the liability of an error much less. This rule will apply not only to gears of this particular angle but to every angle that it is possible to cut on a gear cutter or milling machine and with diametral pitch cutters, and also puts the matter in such a form that anyone able to understand the first principle of trigonometry, can easily determine the pitch diameter of a spiral gear and not have a large sheet full of figures with which to contend. E. M. WILLSON.

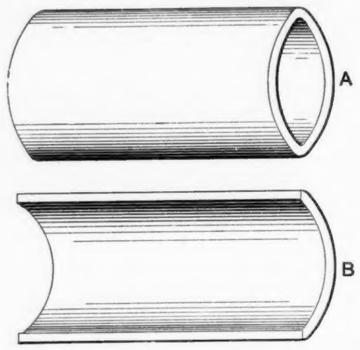
Madison, Wis.

MAKING STEEL CYLINDERS.

Editor MACHINERY:

In a shop which I recently visited, my attention was attracted to some large cylinders of tool steel which were hardened and ground, and an investigation as to the way in which this was accomplished showed some points of shop practice that will, without doubt, be of interest to MACHINERY readers.

Some of these cylinders, which were from 10 to 12 inches long and 5 to 14 inches in diameter, were made in one piece, as shown at A, Fig. 1, while others were made in halves as at B. It was a simple matter to forge the halves but forging the whole cylinders was considerable of a job since they had to be made without a weld. This was accomplished by using a block of steel of the length of the cylinder and of sufficient cross section to form the shell. The block was drilled with a series of longitudinal holes, as shown in Fig. 2, which is an end view of the block. This was then wedged open and forged to the proper shape. In hardening, it was the half cylinders that threatened trouble as it would be practically impossible to harden them without warping unless some



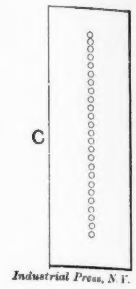


Fig. 1. Steel Cylinders. Fig. 2. Block for Forging Cylinders.

means was provided to prevent it. The means employed in this case consisted of two clamps which were placed over the open side and held the shells securely in shape while they were passing through both the furnace and the hardening bath. These clamps are shown in position in Fig. 3. After hardening, the shells were ground internally on the rig shown in Fig. 4, in which a half shell is shown, mounted for grinding.

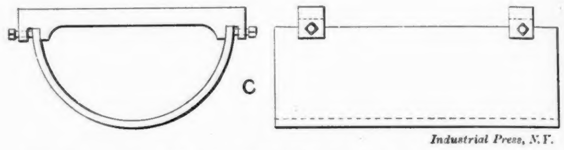


Fig. 3. Clamps for Holding Half Cylinders when Hardening.

This is essentially a boring machine with a revolving wheel substituted for the usual boring tool. One end of the bar is held in a chuck, which is screwed to the spindle of the machine, and arranged so that it may be adjusted radially by means of the hand nut B. The other end of the bar is carried on a similar but simpler chuck on the dead center of the machine. The wheel and belt pulley are mounted upon a

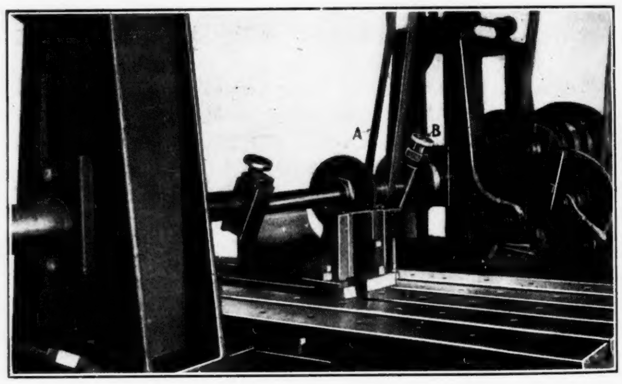


Fig. 4. Arrangement for Grinding the Cylinders.

sleeve which runs upon the bar and is driven at the proper grinding speed by the belt A. The bar itself is rotated at a slower speed with the wheel set sufficiently off center to cause it to grind to the required diameter. When the internal grinding is completed, the shells are ground externally, on an arbor, in the usual manner. H. P. FAIRFIELD.

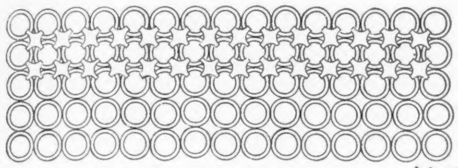
Worcester, Mass.

A SPECIAL PUNCH AND DIE JOB.

Editor MACHINERY:

Not long ago the writer was employed in a shop engaged in the manufacture of a cheap line of sheet metal goods and one of the jobs there encountered seems of sufficient interest to illustrate for the readers of MACHINERY. This was the production of the bodies of the so-called chain purses. These consisted of a series of rings held together by a four-pronged setting. A section of these purse bodies is shown

in Fig. 1; the two lower rows show the rings as they came in strips from the punch, while the two upper rows are shown fastened together by the settings. One of these settings as it comes from the press is shown in Fig. 2. Both rings and settings were formed upon the power press and we will first consider the tools used for making the settings or links that hold the rings together. Referring to Fig. 3,



Industrial Press, N.Y.

Fig. 1. Section of Chain Purse. Fig. 2. One of the Settings.

D shows the cutting die which was made from a piece of tool steel recessed into the block *C* and flush with its upper surface. Over this was fastened the stripping plate *B* containing the slot *A* for guiding the stock. Recessed very carefully into the body of the plate was the circular disk *Z*, which revolved around a central stud. Upon the edge of this disk were cut the pawl and stop-pin notches so as to index the

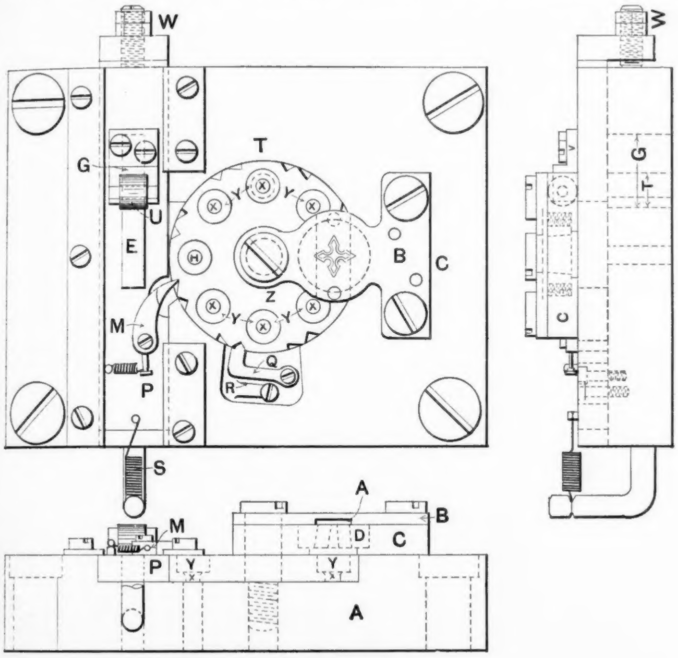


Fig. 3. Die for Making the Settings.

dial eight times to a complete revolution. To the left of the dial was a slide *P*, which carried the indexing pawl *M*, and was provided with a return spring *S* and an adjustable stop *W*. The stop lever *Q*, which worked in a recess in the face of the plate, was actuated by the spring *R*, of sufficient strength to bring the dial into exact position in case the pawl should vary in its action. The eight holes, *X*, *X* were so located in the disk *Z* as to come exactly central with the die as they were brought around by the indexing mechanism. These holes were counterbored at *Y*, the counterbore being a trifle larger at the top than the diameter of the blank so that it could be easily forced to the bottom where it remained until indexed around under the drawing punch which operated at *H*. This punch drew it into the shape shown in Fig. 2 and carried it through the hole *H* out of the machine.

The punch, which is shown in Fig. 4, consisted of three parts—the blanking punch, *D*, which is shown in section in Fig. 5; the drawing punch, *F*, and the cam *G*. Through the center of the blanking punch was a small piece of wire, having a collar at its lower end against which bore a spiral spring. This spring pin was held into the shank of the punch by means of a headless set screw. The object of this spring pin was to push the blank firmly into the recess in the dial and also to prevent the blank from sticking to the punch as it would be apt to do if some such means of prevention were not provided. The drawing punch, *F*, was held in the holder, *E*, by means of a set screw, *K*, but the hole in the shank was considerably deeper than the end of the punch so that if the dial should not index properly, and the punch should strike against it, *F* would slide up into *E* instead of being broken. The cam, *G*, was set so that it would engage the cam roll, *U*, Fig. 3, and thereby index the dial. The hole at *T* was to provide an escapement for chips which, before it was put in, caused some trouble in the working of the dial.

The operation was as follows: The stock, which came in strips, was fed into the slot *A* by means of an ordinary roller feed. As the blanks were cut out they were forced by the spring pin, in the punch, into the bottom of the recess *Y*, where they remained until indexed to *H*, when they were drawn by the punch *F*, Fig. 4, and fell completed out of the machine. With each descent of the punch *X* the cam *G*, engaging with the roll *U*, caused the plate *P* to slide outward sufficiently for the pawl to index the dial one notch. After the cam had ascended, the plate was returned to its original position by the spring *S*.

The punch and die for forming the rings are shown in Figs. 6 and 7 and form a comparatively simple tool. The stock in strips was fed, by hand, into the die at *A* in the direction of the arrow and held firmly against the side *K* by means of the spring-gage *B*. After each cut the stock

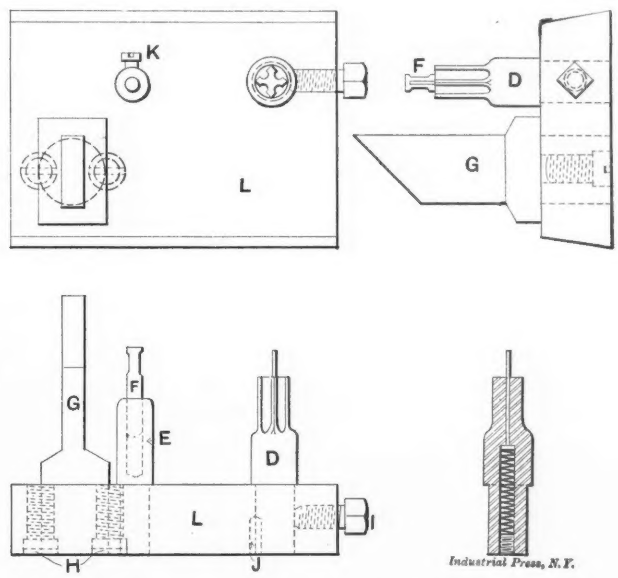
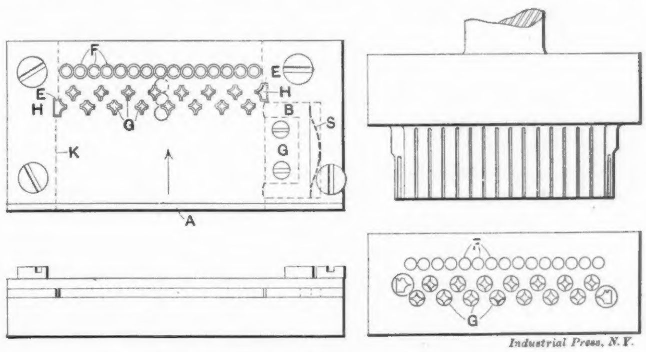


Fig. 4. Punch for the Settings. Fig. 5. Section through the Blanking Punch.

was moved forward until the edge came to the points *E*, *E*, which were very accurately filed on the set edges. The stock first encountered the punches *G*, *G*, which cut out the outside of the rings. Each side of the hole made by these punches was about .003 inch less than a quarter of a circle, so that about .006 inch of metal was left to tie the rings



Figs. 6 and 7. Die and Punch for Making the Rings.

together. After this punching they came to the round punches *F*, *F*, which removed the metal from the center of the rings and left remaining the plate of rings shown in Fig. 2. The settings were then put in place by girls and "set" in a foot press, after which the piece was rolled a couple of times in the hand and the stock between the rings was easily broken, leaving a flexible body. TEDDY.

CUTTING SPIRALS ON THE UNIVERSAL MILLING MACHINE.

Editor MACHINERY:

I have frequently been asked, by shop-men, for instructions for figuring the gearing required for cutting spirals on the universal milling machine, and having done considerable of this work in times past, I thought a letter upon the subject might be of assistance to some fellow workman. The makers of universal milling machines usually furnish tables with the machines, showing the proper change gears for a number of spirals. But many are not content to use the tables blindly; they wish to know the why and wherefore of the rules, so that should pitches be required which are not in the table they would know how to go about it to figure the change gears required. The principle is the same as finding the change gears for cutting screw threads in the lathe, but the lead of the milling machine is much coarser than is found on the lathe and is given as inches to one turn, instead of turns per inch. As the screw of the milling machine has usually four threads per inch, and as the spiral head takes 40 turns of the worm for a revolution, if equal gears are placed on the machine, the lead would accordingly be $\frac{1}{4} \times 40 = 10$ inches to one turn.

It is usually necessary to compound the change of gears for the milling machine. The spiral pitches given in the tables are usually in decimals, which is probably because the pitches are approximations to what the gears actually give. To keep the number of change gears within reasonable limits a comparatively small number of gears may, by compounding, be used for a large number of spirals. Suppose, for example: It is required to find the change gears for a spiral of 1.25 inches to one turn. Then the required spiral placed over the lead of the machine would give the ratio of gears required or $\frac{1.25}{10} = \frac{1}{8}$. This means that the required spiral is $\frac{1}{8}$ of the lead of the machine and that the product of the number of teeth of the driving gears must be 8 times the product of those in the driven gears. Now in order to compound the gears resolve 8 into factors thus: $\frac{1}{8} = \frac{1}{2} \times \frac{1}{4} = \frac{24}{48} \times \frac{24}{96}$ and gears of 24 teeth used as the two driven gears and gears of 48 and 96 teeth as the two drivers would answer if among the set, but as 24 is the smallest gear in the set (usually) and a gear as large as 96 teeth would not be likely to be found in the set we must find the other factors of 8; then $\frac{1}{8} = \frac{1}{3} \times \frac{1}{2\frac{2}{3}} =$

$$\frac{24}{72} \times \frac{24}{64} \begin{array}{l} = \text{driven gears} \\ = \text{driving gears} \end{array}$$

would answer. The 72 T gear could be placed on the screw, 64 for the first gear on stud, 24 for the second gear on the stud and 24 on the worm shafts. It would make no difference if the gears were transposed provided the gears on screw and first gear on stud are the driving gears from the example, for if the 64 T gear was placed on the screw and 72 as the first gear on stud, the ratio would not be changed.

For another example: Required the gears for a lead of 2.22 inches to one turn.

$$\frac{2.22}{10} = \frac{1}{4.5} \text{ nearly} = \frac{1}{2} \times \frac{1}{2.25} = \frac{28}{56} \times \frac{32}{72} \begin{array}{l} = \text{driven gears} \\ = \text{driving gears} \end{array}$$

These gears do not give exactly 2.22 inches to one turn. To find a closer approximation, multiply the ratio by 10, as $10 \times \frac{1}{4.5} = 2.222+$ ins. = actual lead, but 2.22 ins. is near enough for practical purposes. For another example: Required to find the gears for a lead of 60 inches to one turn.

$$\frac{60}{10} = \frac{6}{1} = \frac{2}{1} \times \frac{3}{1} = \frac{64}{32} \times \frac{72}{24} \begin{array}{l} = \text{driven gears} \\ = \text{driving gears} \end{array}$$

To find what spiral a given set of gears will produce multiply the ratio of gears by 10, or divide 10 times the product of the driven gears by the drivers; the result is the number of inches to one turn. Thus, to prove the gears in the last example: $10 \times \frac{64}{32} \times \frac{72}{24} = 60$ inches to one turn.

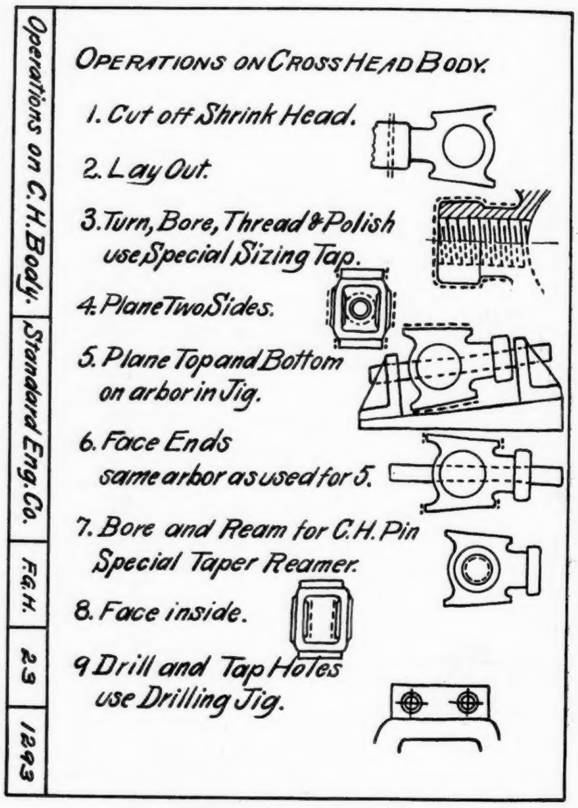
East Providence, R. I. JOHN T. GIDDINGS.

OPERATION SHEETS.

Editor MACHINERY:

I have read, in these columns, a great deal about various shop systems, but have seen very little about systematically outlining the different operations that are to be performed upon a piece of work. It seems to me that this is a very important subject, yet one that has failed to receive its due share of attention.

Before a piece of work is machined the foreman or machinist looks it over and decides upon the most direct and advantageous way in which it can be performed. The time is well spent that is taken for this preliminary planning, as a little forethought often saves a great deal of work. Having determined upon the best method of procedure, the piece is machined, but when the same thing comes up a few weeks later, unless the man is endowed with a good memory the same amount of preliminary thinking must be repeated. This trouble is more noticeable in the case of large work where the successive operations are done by different workmen, under orders from the foreman, so that it devolves upon him to keep run of the order of operations for all of the work under his charge. Now the question is: Having once determined the best way in which to do a piece of work, why not put it on record so that it will be at hand for future reference?



Specimen Operation Sheet.

This plan was followed in one shop with which the writer was connected and the results were such as to justify its more general use. This shop was engaged in building large steam engines, and when the drawings were ready for the shop the superintendent and the different foremen who were in charge of the work would "get together" and plan out the method of procedure. In this conference the head draftsman participated, and as the plans proceeded he made the rough sketches from which later one of the draftsmen would prepare the operation sheets. At this time it became apparent what new jigs and tools would be required, and these were taken under consideration by the chief draftsman. Thus the combined efforts of the different heads of the shop were for a

short time concentrated upon the job in hand, and after that it was only necessary to follow the plans here decided upon. It frequently happens that the first time a job is put through the foreman or machinist will see an opportunity to improve upon the outlined method, and then the sheet is changed in accordance with the suggested improvement. Also any new tools or jigs that may be added are at once entered upon the production sheet.

These operation sheets were made on drawing paper, numbered as a regular drawing, and each foreman under whom the work would come was provided with a blue-print copy. The illustration is a copy of the operation sheet used for finishing the bodies of crossheads. The drawing and lettering was always free hand, with the possible exception of the circles, which can be drawn quicker with compasses. A dotted line indicates the surface that is finished by each progressive operation. Having seen the advantages that were derived from the use of this system, the writer fails to understand why its use should be limited to this particular shop.

George Frost.

[While we share Mr. Frost's enthusiasm in regard to the use of a systematic operation list, we do not think that its use is by any means limited to the shop in which he was employed, as we know of several shops in which similar systems are in operation. Mr. Frost has by no means exhausted this subject, and we should be pleased to receive contributions of sample operation sheets and additional suggestions from others employing similar methods for the systematic production of work.—Editor.]

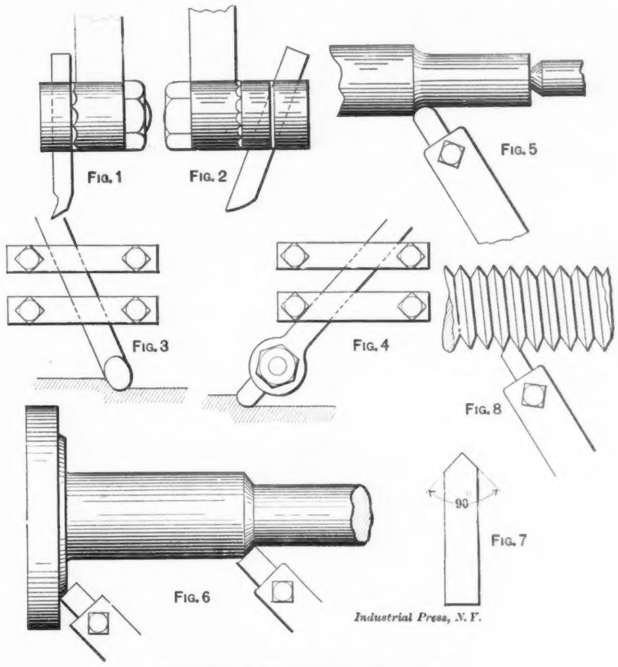
PATENT TOOL HOLDERS AND THEIR USE.

Editor Machinery:

Why is it that in many shops a number of patent holders for hardened steel tools will be found which are but little used or not used at all? There must be some reason for this and no doubt the utility of some patent tool holders is questionable; at least, not all are so adapted to all conditions as to make them of universal advantage. But when you observe side tools, cut-off tools, boring tools and off-set tools of all kinds and sizes, scattered broadcast about the tool-board while men wait for rough smiths to worry out awkward chunks of cast steel for them, and at the same time other men, who are a little more up-to-date and of an intellectual turn of mind, are plowing off the stock with twice the feed, a deeper cut and 30 per cent. more cutting speed than could be expected of those crude forged tools; then something must be wrong somewhere. Of course the whole difference cannot be due to the tool but the machinist who lives in the age of wrought iron when some of us have learned to cut soft steel is the same one who sticks to the tools in vogue "before the flood." To the writer the machine shop contains no greater mystery than the machinist who turns steel, however light the cut, at the old wrought-iron speeds and still holds his job. Those who have practiced a little on cutting speeds for soft steel find that for finishing with light cuts 200 feet per minute is just as easy on a nice sharp Mushet steel tool as 20 feet.

On the question of patent cut-off tools the writer has little to say, owing to the fact that in an experience of twenty years he has not seen a mechanic who could make or use one with any certainty of success. It is my opinion that some day some one will invent a cut-off tool that will be practical, but if such a tool exists at present it has not yet crossed my path.

Planer tool holders seem to be almost practical, and an improvement is suggested that will add to the efficiency of one of the best known forms of planer tool holders. It will be noticed that there is no rake to the cutter used in these tools, unless the shape of the steel is mutilated by top grinding which, if done, becomes worse and worse with each grinding of the tool. A holder should be so designed as to avoid all necessity of grinding the top of the tool and still maintain the same cutting angle until the tool is consumed in actual work. To accomplish this end the writer "doctors" such a tool holder as is shown in Fig. 1 in the manner illustrated in Fig. 2. The slot in the bolt is cut on an angle and a loose collar with a corresponding angular slot is inserted between the shank and the bolt so as to secure the steel tool on at just the proper angle for cutting. It will also be observed that instead of sticking the tool out in front of the holder it is hung on the back side so that it will spring away from the excessively heavy cuts instead of springing into the work. Another suggestion is to unlearn the old habit of setting the tool at the angle shown in Fig. 3. This we learned in our youth and it is difficult to forget, but the advent of the patent tool holder has made the change imperative and allows the tool to be set properly. The cutter should stand against the cut so that the strain due to cutting will come in the direction of the tool support and the rake of the tool is at all times



Patent Tool Holders and their Uses.

in the direction in which the chip naturally travels. A tool set in this way (Fig. 4) will retain its shape with very little grinding and therefore the least waste of time and high-priced steel.

For lathe tool holders the common straight steel holder, as made by a number of manufacturers, is the most efficient. In the writer's experience off-set tool holders are practically unnecessary. As in the case with the planer tool the cutter is run ahead of the holder, as shown in Fig. 5, and this tool should be set as high at the point as good clearance will allow. The tool should be given some side clearance, as well as back, so as to allow a higher setting and consequently

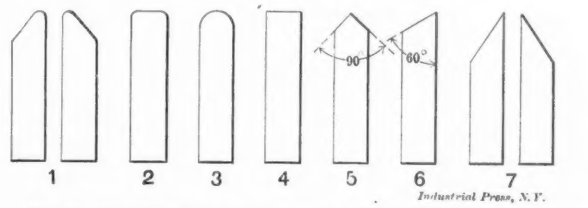


Fig. 9. Complete Set of Tools for Use with Patent Holders.

greater benefit from the rake which, as before stated, is not to be changed by grinding during the life of the tool. The great objection to top grinding is that it gets the point of the tool lower and weaker the more it is used.

It is surprising what a variety of work can be done with the straight tool holder and the small number of inserted cutters that are required for all ordinary operations. An illustration of a few of these applications may be of interest to the lathesman. Take for example the casting shown in Fig. 6, it being desired to turn the hub and face the flange. Observe how with this tool holder the carriage seems always to be just where it is required. With the same setting of the roughing tool, run along the hub and down the flange and then with a single setting of the corner tool (Fig. 7) run a finishing chip over the same surfaces. With slight care in

grinding, this tool is ever ready for use and may be used for a left-hand corner as readily as for a right-hand one.

Threading tools are made from a square piece of Mushet steel ground as in Fig. 8. Notice the angle at which the holder stands while the tool is at work. It is just right to enable the carriage and tool post to clear the faceplate, chuck or dog when threading close up, yet there is not too much of an angle for ordinary thread cutting.

Fig. 9 shows a complete set of the tools that, with a straight tool holder, will accomplish all ordinary lathe work.

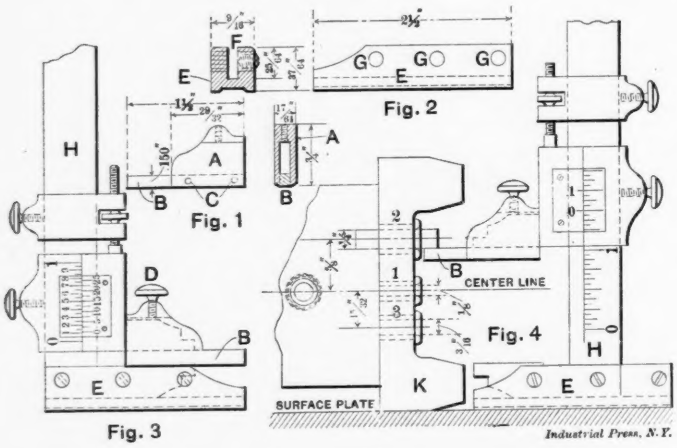
In grinding these tools always take them out of the holder, otherwise they will be too heavy and liable to heat when placed against the emery wheel. If the cutter alone is held in the hand it gives timely warning, by becoming too hot to hold comfortably, and is cooled off before it gets hot enough for the temper to be drawn. S. Byron Welcome.

Los Angeles, Cal.

AN ATTACHMENT FOR VERNIER AND SLIDE CALIPERS.

Editor Machinery:

While vernier and slide calipers are very handy shop tools their usefulness is much more limited than it should be for such expensive instruments. In order to increase the usefulness of these tools I have made the attachments shown in the accompanying sketches and have found them very practical and useful. In Fig. 1, *A* is made of machine steel, while the tongue *B* is of tool steel, hardened and ground and lapped to a thickness of .150 inch, the top and bottom being absolutely parallel. It is secured to *A* by the two rivets *C*, *C*. The thumb-screw *D* (Fig 3) is used to fasten the attachment to the sliding jaw of the vernier or slide caliper. Fig. 2 shows the base, which is of machine steel with the slot *F* milled for the reception of the fixed jaw of the caliper. The set screws, *G*, *G*, are put in at a slight angle so that the caliper will be held firmly and squarely in this base. In Fig. 3 these pieces are shown in the position for forming a height gage, for which purpose the attachment is most commonly used.



As a test of the accuracy of its construction, when the attachment is placed in this position the tongue *B* should make a perfect joint with the fixed jaw of the caliper and the vernier should give a reading of exactly .150. When it is desirable that the tongue *B* should overhang, the base *E* is pushed back even with the stationary jaw as shown at in Fig. 4. In this position it is used for laying out and testing bushings in jigs, etc. The illustration shows the tool in use for this purpose, *K* being the jig to be tested. All measurements are from the center line upon which the bushing No. 1 is placed. Taking this as a starting point we find the caliper to read 1 inch. Bushing No. 2, which is undergoing the test, should be ⅝ inch from this center line. It has a ¼ inch hole, so through it we insert a plug of this diameter. Now adjust the tongue of the caliper to the bottom of this plug (as shown in the cut) and the vernier should read 1.625 minus one-half the diameter of the plug, or 1.500, and any variation from this will show the error of the jig. In this case the top surface of *B* was used and so no allowance had to be made for its thickness. In case the bottom surface is used, .150 must be deducted from the reading of the caliper.

Workmen will agree with me that it is very easy to make a mistake in setting a bushing and that such a mistake is equally hard to detect unless some such means of measuring as this is at hand. It often happens that jigs and fixtures are put into use containing such errors and the trouble is not discovered until many dollars' worth of work has been finished and found worthless.

The sketch shows but one of the many uses to which this attachment may be applied.

The figures given on the detail are correct for making the attachment to be used upon the Brown & Sharpe vernier caliper but for other calipers they would, of course, have to be altered to suit. L. S. Brown.

Derby, Conn.

HOW TO READ "MACHINERY."

Editor Machinery:

"No use to study, wait till you need the knowledge, then go after it. Drop work at the whistle, you need recreation and plenty of rest to drive the cobwebs away. Got all you can do to hold your own job without thinking out Smith's problems, who holds a much better position than you do. Look at the boss; by no means a brilliant man; holds his position by pull. Don't waste time and money over Machinery, nothing in it but a few shop kinks you can never remember, and some technical articles of doubtful accuracy, etc., etc."

Such were the remarks recently made to me upon my inquiry if the speaker had seen certain articles in Machinery, and I have heard the same kind of thing so often before, and seen around me so many otherwise bright young fellows drifting along apparently unwilling to exert themselves in acquiring knowledge, but eager to sit with folded hands while someone else exerts himself in an effort to pound it into them, that I am led to believe that very few of the younger subscribers to such papers as Machinery know *how to read them*, or get their money's worth out of them. I feel quite a contempt for any draftsman or machinist who says he cannot afford a trade paper; why, no one can afford to be without one, or two, or more.

I am convinced, however, that very many subscribers to a paper glance through it in fifteen minutes each month, and lay it away, in the fond belief that in some mysterious manner it is going to benefit them. Just ask among the younger men in your establishment, who takes a trade paper, and having found one, begin to converse with him about any article found in the last issue, and note his replies. He hasn't read that number yet. Go back two or three issues. He has forgotten that article.

Like a good horse, or a full meal, a paper must be used to be found of value. How should Machinery be used?

Read every page. It is not "a fraud two-thirds full of 'ads.'" Despised "ads," an ever-changing cyclopædia of mechanic arts, yet so often ignored. First take a quick glance through the paper for any articles which discuss questions connected with your line of work. Master such articles; if necessary, correspond with the writer. Make a note of such articles as, though of no particular interest now, may be needed in the future. All machine design articles would come under this head for a draftsman, for instance, for, though widely separated from the present line of work, one can never tell what needs the future may bring forth; and so far from waiting till the need is felt, it should be remembered as a truism that no knowledge is needed till obtained. Therefore aim to be prepared. The well-informed man is not he who carries the most scattered information in his head, but he who knows where to find reliable information upon any subject that may present itself. An excellent thing for this purpose is a sample card index outfit sold for $1.25 by several of the makers of such goods. The outfit consists of one hundred ruled cards, a complete set of alphabet division cards, and a set of division cards for days and months, all contained in a very neat case to be kept on the desk or table. When several technical papers are read this case be-

comes an index of all that has passed under the owner's notice upon any given subject. It will be found a good plan to index thus such reference books as one may possess. If each time a subject is looked up it is entered in the index, it is easily found again, and it is surprising how soon such an index becomes valuable, and how little the task of thus completing it by degrees is felt. Glance through the column telling of new business firms starting up. It is well to know who are the people engaged in your business. Better have a place in which to keep their names and addresses, and watch for their "ads" later on. Read the "situation wanted" column to note how many men of your class are advertising for positions, and the "help wanted" column to compare with the former, thus getting an idea of the state of the market for the services of men in your class. As no one with potatoes to sell fails to watch the produce reports, why not keep posted on the market for time and brains if they are your marketable commodity? In the column of catalogues received, you are told the nature and something of the contents of many new catalogues, mention often being made of valuable tables and data contained therein. A request for such catalogues is rarely refused if made in a business-like manner in an inclosed letter, not a postal card; but it should be borne in mind that the receipt of such a catalogue is a favor, and implies a confidence that it will eventually be of benefit to the sender, and therefore one should have a catalogue file in which to keep them.

Coming to the "ads" your employer put in a new boring mill last week; you will find out something about it here, and more if you will send for a catalogue. It is here you will find the first mention of all new tools, instruments, or contrivances to help you in your job, or to help some other fellow to get your job if he knows more about them than you do. Not until each page has been thus studied can the paper be filed with the certainty that you have received all you can get from it.

As to the boss; it is bad medicine to form the habit of thinking that any man above you is there by reason of anything else than sterling merit. Seek to see his good points, he has them you may be sure, and they are the blocks with which he builds. Above all, regard him as a man from whom you have much to learn, and proceed to learn it.

"EXPERIENCE."

* * *

MANUFACTURING CONDITIONS IN CALIFORNIA.

Mr. P. E. Montanus, president of the Springfield Machine Tool Co., has been traveling in the far West in the interests of the company, and in a letter dated February 4, at San Francisco, he writes regarding manufacturing and labor conditions in two large shops, from which we quote the following:

"Yesterday I visited the big shops of the Southern Pacific Railway at Sacramento, and was cordially received by Mr. T. W. Heintzelman, superintendent of motive power, and Mr. H. H. Forney, master mechanic. I was personally conducted through these great shops where 2,700 men are employed. Wages are high. Lathe and planer men receive 35 cents an hour. These shops do not build locomotives, but repair about twenty-two a month as an average. They build new freight cars, oil tanks, and passenger cars, however. The machine shop equipment is fairly good and modern on the whole, although I saw one Bement & Dougherty planer (about 72 in. by 72 in. by 24 ft.) that has been in constant use since 1849, when it was brought around the Horn. They also have lathes in use that are thirty years old, and the foreman said they were better than some modern makes. At these shops they make a fine grade of cast iron, largely from English pig. As is the case at the Union Iron Works at San Francisco, they make a great many small details like screws, nuts, bolts, oilcups, etc., which I think they can buy much cheaper than they can manufacture. The buildings are very extensive, well-built, and practically arranged, but I think they are poorly located, on account of the labor market. They necessarily must pay the highest wages.

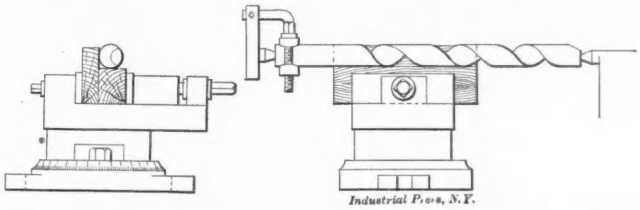
"California has great possibilities for manufacturing and trade will improve year by year if not set back by the labor question, which now is in bad shape. You have probably heard that the Union Iron Works at San Francisco recently lost a contract for a government cruiser, owing to their labor troubles."

CONTRIBUTED NOTES AND SHOP KINKS.

FIXTURE FOR MILLING SLIM DRILLS.

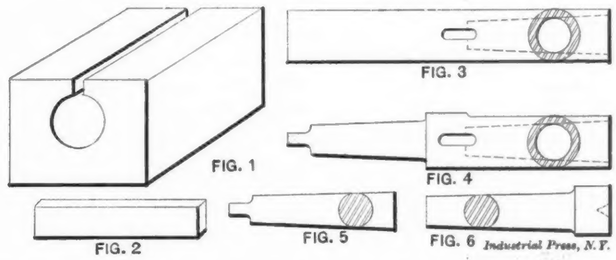
Jas. P. Hayes, Meriden, Conn., writes: In milling a spiral groove in slim pieces, for making twist drills, it is difficult to support the work under the mill with the ordinary rests furnished with universal milling machines.

In the sketch is shown an ordinary milling machine vise which is clamped to the table of the machine between the centers. Two pieces of hard wood of the proper width and thickness and of a length adapted to the length of the work, are held between the jaws of the vise in such a position as to support the work underneath and at one side forming a rigid support against the downward and sidewise pressure of the cutter. I have used this "kink" with very satisfactory results when making long drills for drilling wood, which are made with one groove, similar to a ship auger. This style of drill will drill a straight hole in wood regardless of the direction of the grain.



A NOVEL TAPER SOCKET.

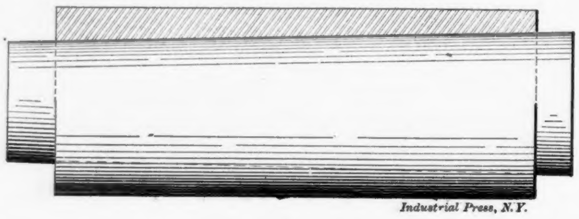
P. B. sends a "kink" illustrating a rather unusual method of holding tapered shank drills. He writes: We used to have a great deal of trouble caused by twisting off the tangs of drills, so I designed a very simple socket that will prevent this without fail. The "kink" consists in milling a flat on the shanks of the taper and making a socket that will fit these shanks. Now the point is to make a drill socket of this description that will be just about as cheap as the ordinary taper socket. To do this a 1¼-inch hole is bored in a solid block of steel and a ⅜-inch slot cut into the hole from one side, as shown in Fig. 1. The drill sockets are turned to 1¼-inch diameter and bored and reamed for the size of shank that is to be used. The pressing mandrel (Fig. 5) is then put into the socket and the socket put into pressing block and placed so that the flat on the mandrel is just below the slot in the block. The key, shown in Fig. 2, is then put into the slot and the whole placed in a fifty-ton hydraulic press where the side of the socket is pressed down to conform to the shape of the mandrel. After pressing, the socket is put into a lathe and turned to its finished shape (Fig. 4), the end being held by the plug shown in Fig. 6.



MAKING THRUST ROLLERS.

G. H. H. sends a "kink" regarding which he says: In making conical rollers for thrust bearings of large size, such as are used on heavy machinery and guns, it is of course necessary not only that all rollers be of the same taper but that the diameter at the large and small ends shall be the same in each roller. To produce the same taper on all of the rolls is a comparatively simple matter, requiring only that the grinder be set properly in the beginning. To obtain the same diameters on this taper would be a matter requiring considerable skill except for the simple manner in which it is accomplished. This consists in grinding the rolls first, for which operation the pieces are left considerably longer than finished length and are ground as nearly

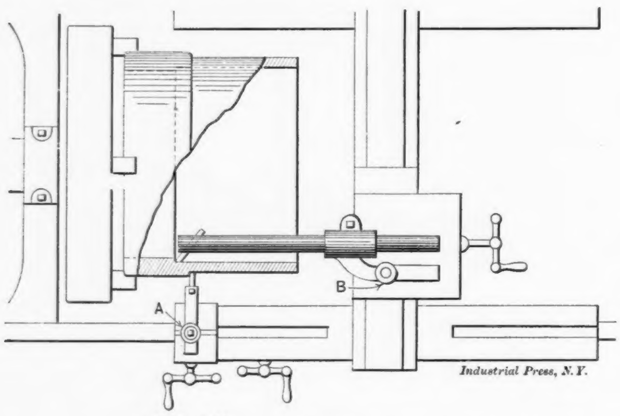
the required diameter as can be done without fine measurements. The roll is then slipped into a gage which is bored to the same taper as the roll and is of just the length of the



roll when finished. With this gage in place the roll is cut off flush with the ends, thus insuring duplication of length and diameter at the ends.

TURNING AND BORING SIMULTANEOUSLY.

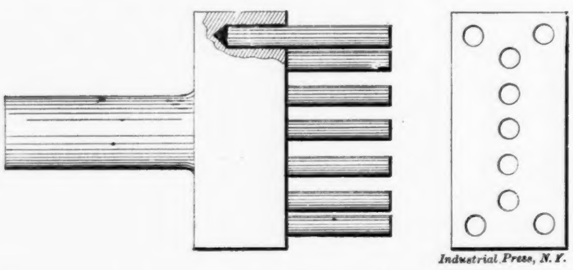
A. McA. writes: We had a large number of bushings which were to be finished both outside and inside, and one of the men suggested that the boring and turning be done simultaneously. In order to do this a compound rest, from another lathe, was mounted upon one end of the carriage and the turning tool mounted in the tool post *A*. The boring



tool was held in an ordinary boring tool holder in the tool post *B*. The arrangement will be clearly seen by reference to the accompanying sketch. In this way we were able to do the work in a very satisfactory manner in about two-thirds of the time that would be required by the ordinary method. This scheme may also be used to advantage for turning piston rings or similar work.

MAKING A PUNCH FOR THIN METAL.

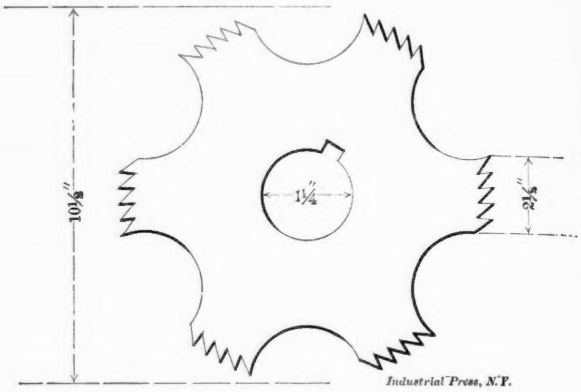
"Teddy" sends us a "kink" in regard to making a punch which is somewhat out of the ordinary. He says: I had occasion to make a punch for cutting a series of small holes about 3-16 inch in diameter and, as the most economical way to do the job, I used pieces of Stubs steel wire fitted to a cast iron punch plate as shown in the sketch.



The method of setting these punches was somewhat odd, at least it seemed so to me when I first saw it done, but it is all right and works perfectly satisfactorily on punches for thin metal. Holes were drilled in the body of the punch plate relative to the die and about 1-64 inch larger than the wire used for the punches. These holes were then filled with soft solder and the plate leveled in a vise. The punches were well tinned and placed in the die. After heating the plate so that the solder would run, the die containing the punches was placed over the plate and the punches tamped to the bottom of the holes. After cooling the tool was ready for use and I have never seen one of the punches come loose.

A HOME-MADE MILLING SAW.

E. J. Buchet, Dubuque, Ia., sends a sketch of a circular saw, concerning which he says: We needed a saw for cutting some piston rings, on the milling machine, and as we were in a hurry and had nothing else at hand we made it from an old circular saw which was about one-quarter inch thick. We first made it with teeth all around the circumference, of about one-half inch circular pitch. Four attempts were made to temper it but it warped so badly



that we gave it up for a bad job. We then tried making it as shown in the cut, having the teeth arranged in sections of five teeth each and tempering one section at a time, drawing the temper with an alcohol blow lamp. In this attempt we were very successful, producing a saw which, when ground slightly concave for clearance, did very satisfactory work.

A SCALE AND SQUARE ATTACHMENT.

M. H. Ball, Watervliet, N. Y., sends the sketch of a device for attaching a scale to a square. He writes that the combination makes a very convenient tool to use when setting up work for keyseating, as is illustrated in Fig. 2, in which *S* is the shaft to be splined and *C* the milling cutter. It is also a very handy tool for truing up work on the boring mill or lathe.

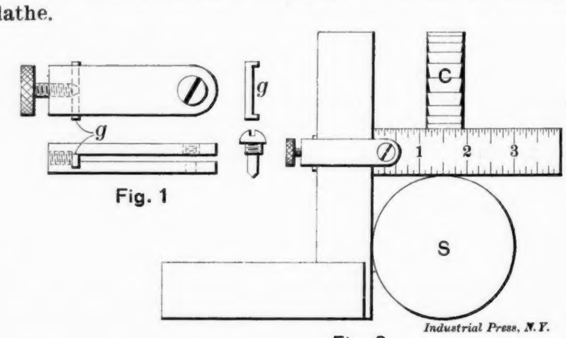


Fig. 1

Fig. 2

Fig. 1 shows the construction of the parts, which are made of dimensions to suit the size of the scale and the square. For the combination to be successful, it is essential that the blade of the square be the same thickness as the scale.

* * *

The *Practical Engineer* quotes from some source the following note which, if correct, should be of considerable practical value where trouble is experienced from the clogging of flues and chimneys by the soot of soft coal: "Zinc is a peculiar metal in many respects. It volatilizes easily, and the oxide thus produced has a strong affinity for carbon. If one's surface chimney is clogged up with soot, and the owner desires to get rid of it, all that is necessary is to throw a little zinc scrap into the fire. Any old zinc will do, and very little will suffice to keep the chimney clean if used about once a week. The vapor of zinc oxide seizes upon the carbon of the soot and forms a new chemical compound, part of which goes up the flue and part falls to the bottom, to be shoveled out as ash."

HOW AND WHY.

A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST.

Give all details and name and address. The latter are for our own convenience and will not be published.

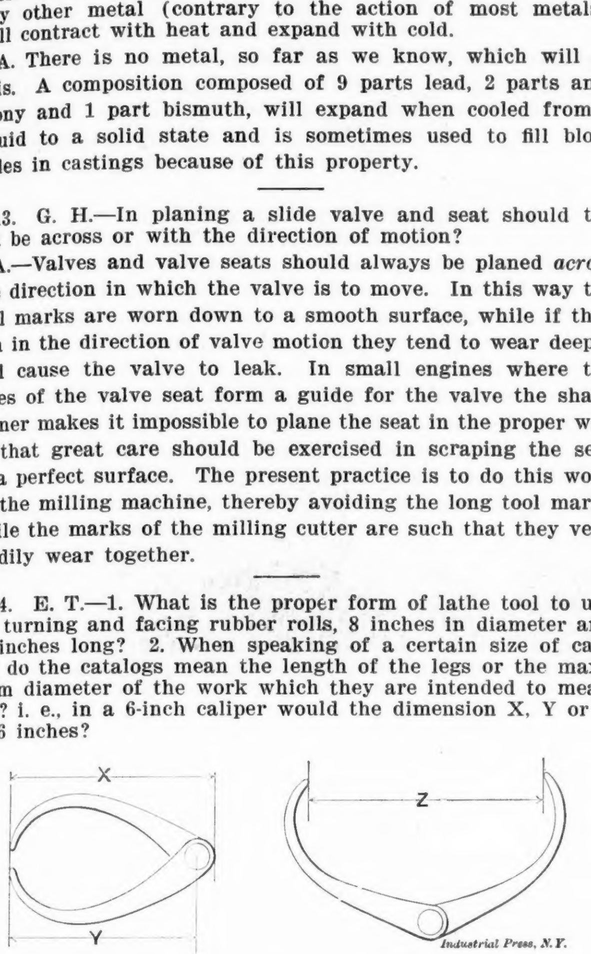
12. J. E. C. I should like to ascertain if antimony or any other metal (contrary to the action of most metals), will contract with heat and expand with cold.

A. There is no metal, so far as we know, which will do this. A composition composed of 9 parts lead, 2 parts antimony and 1 part bismuth, will expand when cooled from a liquid to a solid state and is sometimes used to fill blowholes in castings because of this property.

13. G. H.—In planing a slide valve and seat should the cut be across or with the direction of motion?

A.—Valves and valve seats should always be planed *across* the direction in which the valve is to move. In this way the tool marks are worn down to a smooth surface, while if they run in the direction of valve motion they tend to wear deeper and cause the valve to leak. In small engines where the sides of the valve seat form a guide for the valve the sharp corner makes it impossible to plane the seat in the proper way so that great care should be exercised in scraping the seat to a perfect surface. The present practice is to do this work on the milling machine, thereby avoiding the long tool marks while the marks of the milling cutter are such that they very readily wear together.

14. E. T.—1. What is the proper form of lathe tool to use for turning and facing rubber rolls, 8 inches in diameter and 14 inches long? 2. When speaking of a certain size of caliper do the catalogs mean the length of the legs or the maximum diameter of the work which they are intended to measure? i. e., in a 6-inch caliper would the dimension X, Y or Z be 6 inches?



A.—Hard rubber is one of the most difficult substances known to machine and it is practically impossible, with steel tools, to produce accurate work. Some peculiar property of hard rubber, developed by the combination of ingredients necessary for vulcanizing, causes it to blunt the edge of the hardest and best tool steel so quickly that it is hardly possible to machine even a small piece with accuracy. In works where any great amount of rubber turning is to be done black diamonds, or carbons, mounted in steel holders are used with very satisfactory results. These are quite expensive but have good wearing qualities and are capable of producing very accurate results. 2. This question was referred to nearly all of the manufacturers of calipers and with one exception they state that the rating refers to the distance, *Y*, from the center of the spool or rivet to the point of the leg, while the capacity is somewhat in excess of this. The one exception stated that the rating referred to the capacity of the caliper but that this was usually equal to the distance from the center of the pivot to the point of the leg.

15. L. E. V.—Will you kindly inform us what acids are employed for pickling castings and the methods employed in using the same? We desire this information to apply to large as well as small work.

Answered by Mr. H. E. Field, Ansonia, Conn.

A.—Two acids are now in general use for pickling castings. Sulphuric acid, or vitriol, and hydrofluoric acid, under various commercial names. The action of these two acids in pickling is entirely different. The vitriol soaks through the sand on the outside of the casting and attacks the iron beneath, and, thus loosened, the sand falls from the casting. The hydrofluoric acid acts directly upon the sand, and dissolves it from the outside of the casting. The use of sulphuric acid is much more general and is more convenient in many ways. It requires but two tanks, one for acid and one for water. Hydrofluoric acid requires for pickling purposes three to four tanks. One for acid, one for water, one for an alkali, and sometimes a fourth for water. The arrangement of the tanks, and method of handling the castings, depend wholly upon the amount of castings to be handled. Small foundries, where but comparatively few castings are pickled, are usually fitted up with a tank filled with vitriol, with a sloping shelf on the sides. The castings are placed on these shelves and the vitriol is poured over them with a wooden dipper and the acid allowed to drain back into the tank. This is repeated until the sand is loosened. The castings are then rinsed in water. An inexpensive device may be arranged by having the shelves surrounding the tank work on a bearing in the center, and tip both ways. While the acid is on the castings they slant toward the acid tank; when they are to be rinsed with water, the shelf is tipped slightly the other way by a lever, and the water is turned on them by means of a hose or pails. In foundries where a much larger number of castings are handled, more extensive arrangements are necessary. Small cranes are used to lower the shelves of castings into the tanks where they are allowed to remain until the sand has become loosened. They are then lifted from the tanks, the acid allowed to drain off, when they are conveyed by the crane to a tank of water, in which they are immersed, to rinse off the acid. The length of time which the castings should be left in the acid depends entirely upon the practice in that particular foundry. Hot iron will eat into the sand more than dull iron, and the castings will require a longer pickling. Heavy castings will require a longer time in the acid than lighter ones.

When hydrofluoric acid is used the castings do not require to be left in the acids as long as when vitriol is used. In this case the shelf containing the castings is lifted from the acid, lowered into a bath containing water, and rinsed, then carried to a third bath containing an alkali solution, and finally rinsed with water. The soda solution is necessary on account of the strong action of the hydrofluoric acid. The necessity of this third washing has prevented a more general adoption of hydrofluoric as a pickling acid. Where the conveniences make its use practical it has been found to be very satisfactory. The above applies wholly to the smaller class of castings. It is more economical to lead the molds for larger castings than it is to pickle the castings afterward. When the molds for heavy castings are not leaded the heavy mass of iron eats so far into the sand as to make the removal of the sand by acids a long and tedious process, and one which is resorted to only when, through improper blacking, the iron has eaten into the sand.

16. A. M.—I have recently had an opportunity to examine the patent reports in a public library and was surprised to find so great a number of patents on rotary engines. As many as 90 have been issued in one year, and nearly 600 in ten years. As I have never seen but one rotary engine, and the *outside* of that, I was interested in reading the claims and examining the drawings of the patents to find what the *inside* construction of some of them looked like, and found great similarity in the different designs. Now what I want to know is, what is the matter with the rotary engine? Are the difficulties financial, mechanical or otherwise? Can you refer me to some good book on rotary engines?

A.—There have doubtless been rotary engines invented that, if properly worked out, would have given excellent satisfaction, though we believe not as good satisfaction as the reciprocating engine, except, perhaps, for some special uses. The main reason why the rotary has gained no headway is because there has been no demand for it. Many have imagined that there was some mechanical loss of power involved in converting reciprocating motion into rotary motion, which would be done away with in a rotary engine. As a matter of fact, the only loss of power in the reciprocating engine comes through friction, which must exist in any engine, and which might or might not be as great in the rotary as in the reciprocating type. The ordinary engine has been found well adapted to hard and continuous usage, is easily constructed, and can be so designed as to operate with the consumption of but little steam. There is no probability that a rotary engine would be

particularly better in respect to the friction loss or any of the other points mentioned than its older rival, and so, as we say, there has been no demand for its development except in the minds of inventors. Beyond this, there are certain mechanical difficulties in the way of the rotary engine which would tend to hinder its introduction, as follows: First, it is not easy to design a rotary engine to cut off steam at any desired point in the stroke, so as to produce what is called an automatic engine, although this has been done in a number of instances. Second, the diameter of a rotary engine increases directly as the power; that is, if a 10 horse power engine were two feet in diameter, a 20 horse power engine of same width or thickness and running at the same speed would have to be four feet in diameter. With a reciprocating engine, the power increases as the square of the diameter and doubling the diameter quadruples the power. Third, the sides of a rotary engine which constitute the rubbing surfaces are in the form of concentric rings of different diameters, points in the outer rings traveling much faster and wearing faster than those in the inner rings. We would therefore not expect a rotary to have the best of wearing qualities. Fourth, to use steam economically the surfaces of an engine which are alternately heated by the hot steam from the boiler and cooled by the exhaust steam should be as small in extent as possible, in proportion to the quantity of steam used, in order to reduce the condensation of the steam in the engine. This is a vital point that is not considered in most rotary engines. As far as we know, no rotary engines have ever been built to develop any considerable power. We have never heard of one as large, even, as 100 horse power. As explained above, however, it would be necessary to build them of very large diameter for large powers, unless they were designed to run at very high speed. In the past there has been no market for very high speed motors, because it has always been necessary to belt down the speed before machinery of any kind could be driven. With the introduction of alternating current motors and generators, however, there has come a demand for high speed engines to drive the generators, which the present type of large reciprocating engine is not well adapted to fill. The outlook for the rotary engine of the future, therefore, would seem to be brighter than its record in the past, were it not for the fact that it has a worthier and more successful competitor in the steam turbine. While there are some problems difficult of solution in connection with the turbine, it seems to have every advantage of the rotary engine and but one of its disadvantages—high speed, and to have certain features of value all its own. There is no book published on rotary engines.

* * *

A writer in the *Scientific American* suggests that plumbago packing rings of special design could be profitably employed in superheated steam engines, gas engines, and other heat motors in which a high temperature is employed. Plumbago, or graphite, is unaffected by heat and is capable of being molded into permanent form suitable for packing rings, which are now uniformly made of metal. The chief expected advantage is the mirror-like surface and polish that such rings would impart to a cylinder.

MOTOR DRIVES FOR RADIAL DRILLS.

Last month were published illustrations and descriptions of standard planer drives for electric motors recently adopted by the Gray Planer Co., Cincinnati, O. The Bickford Drill and Tool Co., Cincinnati, have adopted a similar plan for their radial drills and the illustrations herewith show three standard motor equipments that are now regularly provided. In Fig. 1 is shown a radial fitted with a constant speed motor set on an extension to the base. Power is transmitted to the gear box by means of a Renold silent chain which, through the use of suitable sprocket wheels, gives with almost any make of motor correct speeds for all sizes of drills given on the standard speed plates furnished with the radial. The drill is driven through the speed box at the base of the drill column by which the speed variation is obtained. The starter and cut-out for the motor are located just back of the gear box.

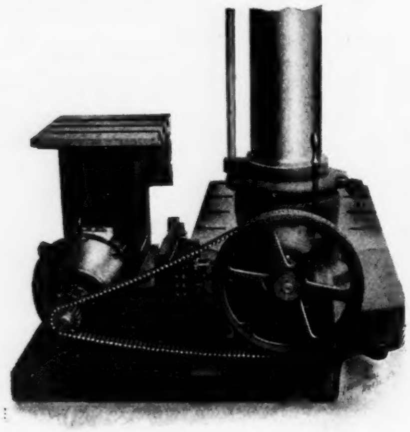


Fig. 1. Constant Speed Motor and Chain Drive.

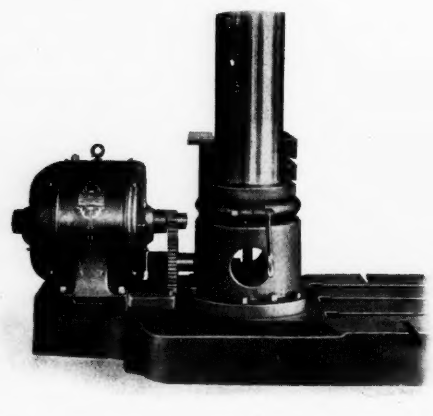


Fig. 2. Variable Speed Motor and Geared Drive.

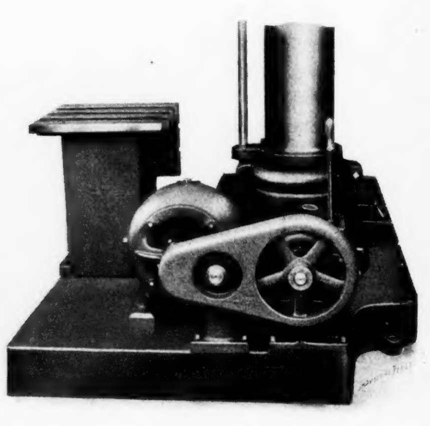


Fig. 3. Constant Speed Motor with Change Gear Drive.

In Fig. 2 the radial is driven by a variable speed motor in which the speed changes are obtained by inserting resistance in the field circuit. The motor sets on a bracket made to fit the standard base of the drill and transmits power to the machine through a single pair of gears which, by means of a rheostat and the back gears gives approximately correct speed for all sizes of drills from a ½-inch to a 3½-inch drill.

Another equipment, Fig. 3, retains the gear box for speed variation with a constant speed motor, but instead of using the chain the power is transmitted to the gear box by means of two spur gears and a rawhide pinion which, by merely altering the number of teeth in the pinion to suit the speed of the motor it is desired to use, furnish a correct range and graduation of speeds for all sizes of drills given on the standard speed plates.

* * *

One of the troubles incident to the operation of third-rail electric traction systems arises from accumulation of ice on the third rail during sleet storms. The effect of the ice coating is to interpose a film of high resistance between the collector shoes and the charged rail, which seriously impairs the efficiency of such systems, causing sparking and loss of contact. New Yorkers had a painful illustration of this recently on the Manhattan Elevated Railroad. Another serious objection to the third-rail is its danger to workmen on the track. On the Manhattan Elevated Railroad two heavy timbers are located close to the rail on each side to prevent objects falling on the rail, or the workmen carelessly stepping upon it, but these are not sufficient safeguard, as proven by a number of accidents. What puzzles the lay mind is why the rail on this system is not protected by some sort of a ledge or roof open at one side to allow the conductor shoe to come in contact. While such construction would not be a total preventative of trouble from ice storms, it would largely mitigate it, and would reduce danger to workmen to a minimum. What promises still better is an inverted third-rail system invented by L. E. Walkins, Springfield, Mass., in which, as the name implies, the rail is turned upside down in an insulated trough, the conductor shoe making contact from the bottom. The rail and its insulation sheath are supported by steel brackets located about 15 feet apart.

A FRICTION WATER WHEEL GOVERNOR.

In using the turbine for driving electric generators a most efficient regulator is needed to meet the exacting requirements of electric light, power and railway service. For this purpose turbine governors of various styles and makes are now in use and from time to time new designs are being perfected for obtaining closer regulation and more constant speed. The regulator which is here illustrated was built by the Woodward Governor Co., Rockford, Ill., and has proved very successful after a severe test at the three-phase power plant of the United States arsenal at Rock Island, Ill., where three governors are used with fourteen 50-inch turbines. These governors are required to close the gates from full open in six seconds and with the severe changes due to the operation of large induction motors the greatest temporary fluctuation does not exceed three per cent.

In another plant at Quebec, two governors are employed, each controlling four 51-inch horizontal cylinder gate turbines and operating the full range of the gate in five seconds. These cases serve to illustrate the class of work that a turbine governor has to perform.

This governor is driven by a belt, from the line shaft of the installation, running on the large pulley shown at the back in Fig. 1. Secured to the main shaft, which is driven by this pulley, is a compressed paper friction disk. On each side of this disk is a friction pan, the hub of which is cut as a pinion for driving the large spur gears shown on the operating shaft at the front of the machine. The main shaft, upon which the paper friction is mounted is free to slide in its bearings so that the friction disk may be forced into contact with one or the other of the friction pans. When it is forced into contact with the right-hand pan the pinion upon the hub drives one of the large gears and causes the shaft to revolve in the proper direction for closing the gate. When the disk is forced into contact with the other pan the operating shaft is driven through the medium of an intermediate gear, and it is caused to revolve in the opposite direction, thus opening the gate

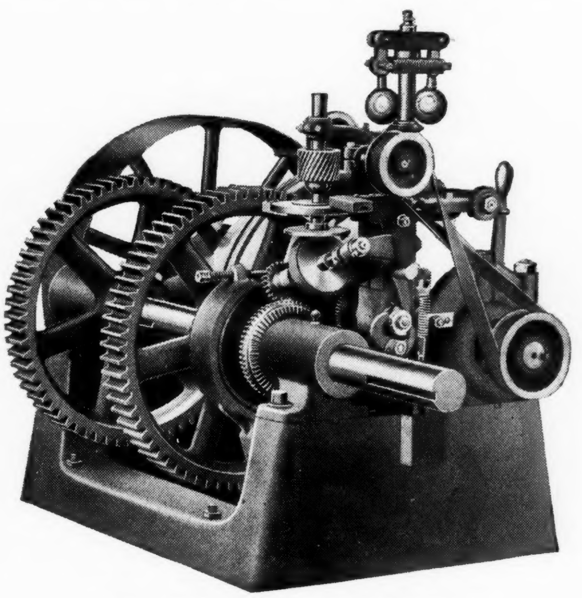


Fig. 1. Woodward Water Wheel Governor.

wider. This constitutes the regulating action of the governor and it is controlled by the governor proper, which is shown in detail in Fig. 2.

The speeder balls are driven independently from the main shaft of the installation by a belt running on a pulley at the back of the column. In front of the column is a cam which revolves constantly, being driven by a cross belt from the main shaft and a spiral gear. Above and below this cam will be noticed two arms or tappets which project inward toward the center. When the speed is normal the cam revolves between these tappets without engaging either of them. With a variation of the speed and a corresponding elevation or depression of the speeder balls, the vertical shaft of the speeder raises or lowers, carrying with it the tappet arms and tappets; and one or the other of them, depending upon whether the speed is slower or faster than the normal, engages the cam and is immediately forced out from the center. This motion is transmitted through suitable crankshafts to the main shaft, on which the friction is mounted, and it is forced into contact with the opening or closing friction pan. This causes one or the other of the pans to revolve, as before described, and operates the turbine gate.

The cam mechanism is capable of very close adjustment, enabling the governor to act on so small a change of speed that for the ordinary conditions of lightning service, no perceptible variation of speed will be allowed. At the same time the governor will not act upon the gate when the speed and load are steady, and consequently there is much less wear on

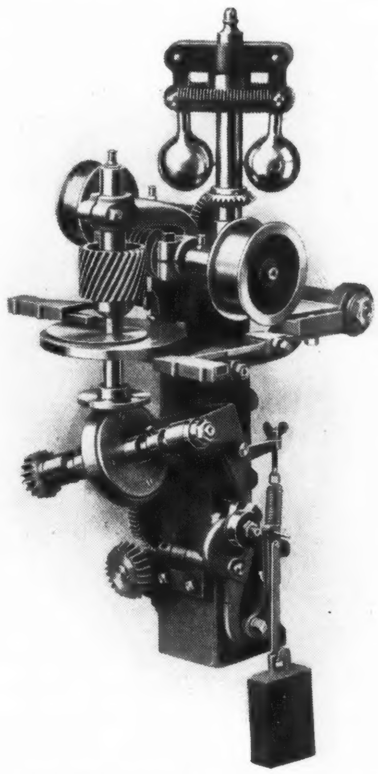


Fig. 2. The Controlling Mechanism of the Woodward Governor.

the gate mechanism than with a governor that keeps the gate in continuous motion although so slight as not to affect the speed.

In hydraulic regulation, as well as in the regulation of steam, some mechanism is required to prevent the governor from racing and in this controller this is provided for by the disk and compensating wheel shown at the front of the column. The disk, which is fastened just below the cam and revolves with it, is concave and rests upon the periphery of the compensating wheel. The oblique shaft which carries the compensating wheel is geared, at its lower end, to the operating shaft so that it revolves only when there is a movement of the gates. The shaft is provided with a square thread and the wheel, which is tapped to match, rides upon the threaded portion.

In operation, the principle is as follows: When the speed is normal the compensating wheel seeks the center of the disk which is supported upon it because this disk is constantly revolving with the cam. When a movement of the gates occurs the compensating shaft is revolved and the wheel will travel along its shaft in such a direction that it will separate the cam from the tappet when the gate has been moved to that point which will give the correct speed, after the momentum of the machinery has been overcome. During this interval the disk will return the compensating wheel to the central position. This device can be designed to properly compensate for any condition, as the time element can be varied, not only by varying the pitch of the screw, but also by varying the speed of the oblique shaft with a change of gears.

* * *

Better have a poor mill under a good foreman than a good mill under a poor foreman.—*The Wood-Worker.*

BEARINGS FOR LIGHTHOUSE LENSES.

One of the problems often confronting the engineer is to provide a suitable bearing for a vertical revolving shaft and when this shaft carries a heavy weight at its upper end and revolves at a high rate of speed the problem becomes one of considerable consequence. In no place is a bearing of this nature put to more severe test than where bearings are used to support the heavy lenses of the revolving lights in a modern lighthouse. Through the courtesy of the United States Lighthouse Board we publish the following description of the bearings used for this purpose:

Under the old system of revolving lights, which is still largely in use, the lens is supported by an arrangement known as a chariot and upon which it turns. This consists of a number of wheels connected together and running upon a circular steel track placed on top of the lens pedestal. Usually there is another set of friction wheels fastened below the baseplate of the lens, but running horizontally against a vertical collar, the object of which is to prevent lateral motion. The best speed obtained with this arrangement for the higher order of lenses, viz., the 1st, 2d, and 3d orders, is about one revolution in two minutes, and for the lower orders —4th, 5th, and 6th—about one revolution in one minute.

With the introduction of the new system of "lightning lights" with lenses consisting of but one, two, three, or four

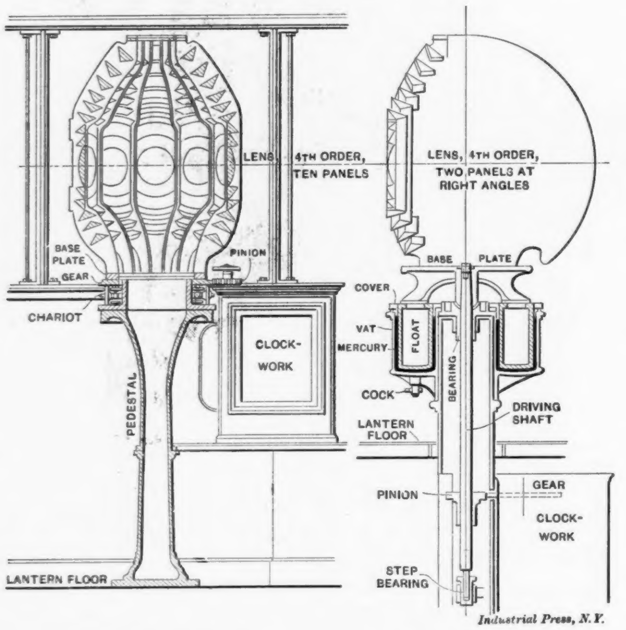


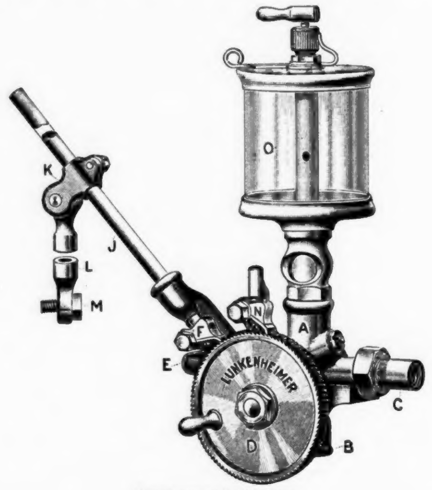
Fig. 1. Chariot Bearing. Fig. 2. Mercury Bearing.

panels—instead of the old style many-sided lenses—and giving flashes of about 1-10 of a second duration at intervals of five seconds—it was found that the chariot was altogether unsuited for the purpose, because it developed too much friction, and the problem was solved by supporting the lenses upon an annular cast-iron float in an annular cast-iron vat or pot—both neatly turned—containing mercury, the free or clearance spaces between the two being about ⅛-inch on the sides and about ¼-inch on the bottom.

In order to prevent lateral motion and rubbing between the float and vat, the horizontal friction wheels, mentioned above, are sometimes retained, but more generally the object is accomplished by a vertical shaft, the pressure on whose toe, due to the weight of the lens, is almost wholly relieved by the buoying effect of the mercury. Usually the vat is arranged so that it can be lowered for examination and repair, and a cover is provided to prevent foreign substances from falling into it. It is customary to cover the mercury with a layer of paraffin oil so as to prevent evaporation. By this arrangement the friction is reduced to a minimum, being probably a little more than that between the mercury and the turned cast-iron float, and enabling speeds of about one revolution in ten seconds in the higher orders, and of about one revolution in four seconds in the lower orders to be obtained.

A MECHANICAL OIL CUP.

In many cases where there is a demand for something more reliable than hydrostatically operated lubricators, a mechanically operated oil pump has been found very satisfactory. The advantage of this method of lubrication is that the oiling is absolutely positive and all of the oil that is fed to the



Mechanical Oil Cup.

pump is bound to be forced into the steam chest or cylinder of the engine. The mechanical oil cup, shown in the illustration, has connected to it a small pump which is operated by the rotation of the crank disk *D*; the disk being driven by means of the ratchets *F* and *N*. To operate these ratchets the rod *J* is connected to one of the eccentric rods, or other moving part of the engine by means of the couplings *K* and *M*. By moving the part *K* up or down the rod, the stroke of the pump can be lengthened or shortened, as desired, thus regulating the amount of oil fed by the pump independent of the feed from the oil cup.

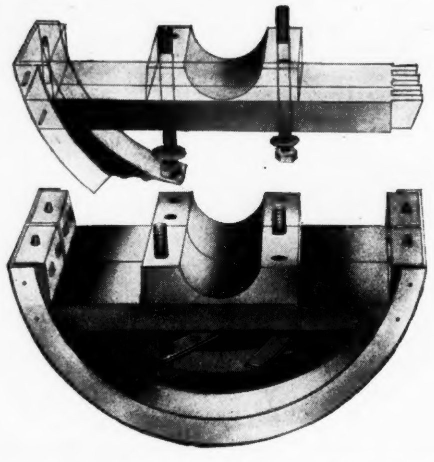
The ratchet wheel *D* is provided with a handle whereby it can be rotated by hand in case it is desirable to force a quantity of oil at any time, as, for example, when starting the engine.

The bottom of the pump body, *B*, is tapped to receive a stud, so that it can be placed in any desired position, and the outlet, *C*, is piped to the steam chest or steam pipe of the engine. This cup is the product of the Lunkenheimer Co., Cincinnati, Ohio.

* * *

THE HERCULES STEEL FACE PULLEY.

One of the latest developments in the line of wood pulleys is the Hercules steel face pulley, shown in the cut, which is the product of the Smith Stamping Factory of the Federal Manufacturing Co., Milwaukee, Wis. This pulley is constructed with a wood center and arms, and has a face formed of



a double flanged steel ring, which is securely fastened to the wooden arms both by bolts through the face and by rivets through the flanges. This pulley is made in halves and is very light, thus possessing the advantages of the wood split pulley, while the steel face gives it the strength and wearing qualities of a steel pulley.

NEW TOOLS OF THE MONTH.

A RECORD OF NEW TOOLS AND APPLIANCES FOR MACHINE SHOP USE.

MANUFACTURING MILLING MACHINE.

The manufacture of the standard parts in large quantities in gun shops, sewing machine and typewriter factories, etc., has evolved a simple and compact type of milling machine, such as that shown in Fig. 1, which is one of the latest productions of the Garvin Machine Co., New York.

The head, bed and saddle are cast in one piece, making a very rigid construction, and as in machines of this class little adjustment is required, the adjustment provided is confined to the cutters, moving them in and out on the arbor and raising the spindle up and down. The spindle is taper and runs in a solid self-oiling bronze box with hardened and ground thrust washers. It is carried in a large block fitted with taper gibs at the rear and adjusts up and down in the column of the bed. The block is clamped at both ends, at any height, by the bolts at the top of the column. The steel arm is also carried in this block, so that the arm and spindle

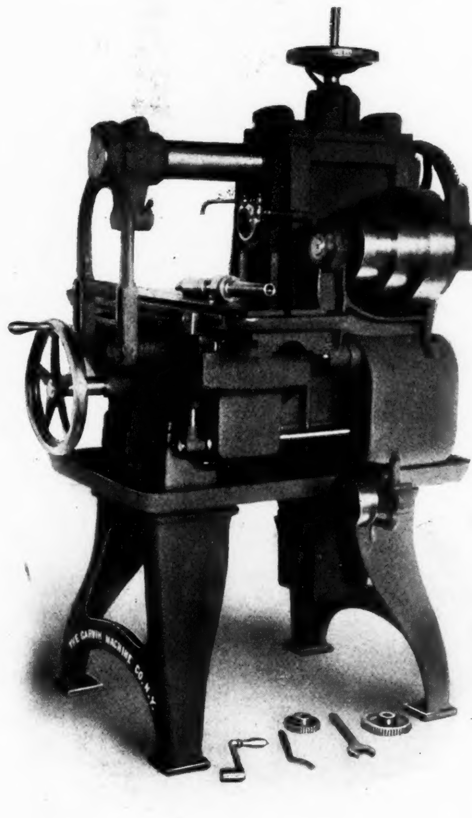


Fig. 1. Garvin Manufacturing Milling Machine.

move together and a substantial brace yoke is provided. The spindle is raised and lowered by the hand wheel, with micrometer reading, at the top of the column and locked by jam nut below the wheel. This construction and method of adjustment is convenient in setting the machine and secures an absolutely solid support for the spindle.

The arrangement for side adjustment of the collars on the arbor is important and shown in Fig. 2. The shoulder of the arbor is fitted with a fixed notched collar, *A*, each notch corresponding to 1-1000 of an inch. Set up against the shoulder of the arbor is another notched collar, *B*, which locks with the notches in the collar *A*. Screwed on the collar *B*, but keyed to the arbor, is the collar *C*. When the cutters are to be adjusted the nut on the outer end of the arbor is loosened until the collar *B* can be moved out of mesh into other notches in the collar *A*, and then the collar *B* is turned as many notches either way as it is desired to move the cutters thousandths of an inch, and put back in mesh and the whole tightened up again. It is evident that when the collar *B* is turned it will force the collar *C* in or out, and when *B* is put back in mesh with the notches in the fixed collar *A*, the setting is absolutely locked and cannot change. The notched teeth do not bottom, and no strain is transmitted through them in any way. The arbor is held by a draw-in rod.

The back shaft carries a large cone and is fitted with ring oilers and linked to the spindle to maintain gear distance, being geared 5 to 1. The table is wide and deep, and has a large oil space all around with an overflow opening on the inner side. It is fitted with square gibbing and large bearing surfaces on the bed. The feed is positively driven by chain, with tightener, through drop-forged hardened worm gears

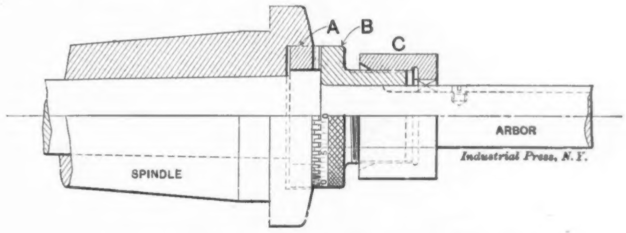


Fig. 2. Spindle of Manufacturing Milling Machine.

connecting to the table feed screw. The movement of the table is by screw to secure steadiness, and is fitted with ball thrust for easy quick return by the large hand wheel and quick gearing, which gives a movement of 1½ inch to one turn. The feed is thrown in by the lever at the front end of the saddle and tripped by a knob at the same point. All these trip parts are enclosed in the saddle and removed from contact with chips and dirt. The oil pan is provided with tipping oil pot and fitted with pump and piping, and extension shields are provided to catch all drip from the table. All driving and feed gearing is enclosed.

SLOTTING ATTACHMENT FOR THE MILLING MACHINE.

The illustrations given herewith show a new slotting attachment for the milling machine which has a number of points that commend it to toolmakers, diemakers or others having use for such a device. Fig. 1 is a photograph of the attachment as it is applied to the milling machine, while the details will be clearly seen by reference to Fig. 2, next page. This attachment had its inception in the shops of the Wm.

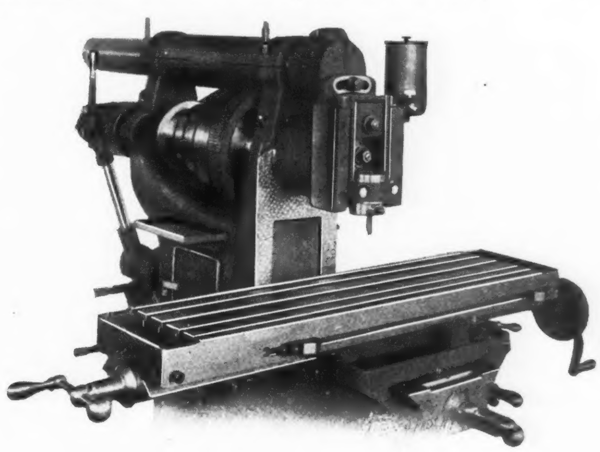


Fig. 1. Slotting Attachment on Milling Machine.

L. Gilbert Clock Co., Winsted, Conn., where the first one was built from designs made by their superintendent, Mr. Thos. W. R. McCabe, in 1895. Several years ago The Cincinnati Milling Machine Company purchased Mr. McCabe's designs, which were the basis for the design of the attachment shown herewith.

It consists essentially of a housing which clamps to the extension of the front spindle bearing, and is supported by the overhanging arm. A crank disk driven by an arbor held in

the milling machine spindle imparts a reciprocating motion by means of a pitman to the slide which carries the tool. This crank has a T slot extending across its face, in which the crank pin is held; and the length of stroke may be varied by adjusting the crank pin toward or away from the center of the crank disk. The attachment may be set at any angle up to 10 degrees on either side of the vertical position for clearing dies, etc. This is accomplished by swiveling it about the milling machine spindle as a center, and since this is also the center of the crank the angularity between the pitman and slide is always constant and the length of stroke is not disturbed by swiveling. The tool is held in a "clapper box" which, in turn, is held in a swivel block that is graduated in degrees and may be swiveled through a complete circle and clamped at any angle. It has a stroke of from 0 to 2 inches on the small sizes, and from 0 to 3 inches on the large sizes. The distance between center of milling machine spindle and bottom of clapper box when it is at the top of the stroke is about 5 inches on all sizes, which gives an unusually large amount of room between the attachment and the top of the table when the latter is in its lowest position. The center of the tool is 9¾ inches from the face of the milling machine column, on all except the attachment for the smallest size miller, and it will be seen from the illustrations that this space is all clear and available for work—there being no parts of the housing that project below the tool holder. There is an adjustable taper gib provided for taking up the wear on the slide. The attachment is made by The Cincinnati Milling Machine Company, Cincinnati, Ohio.

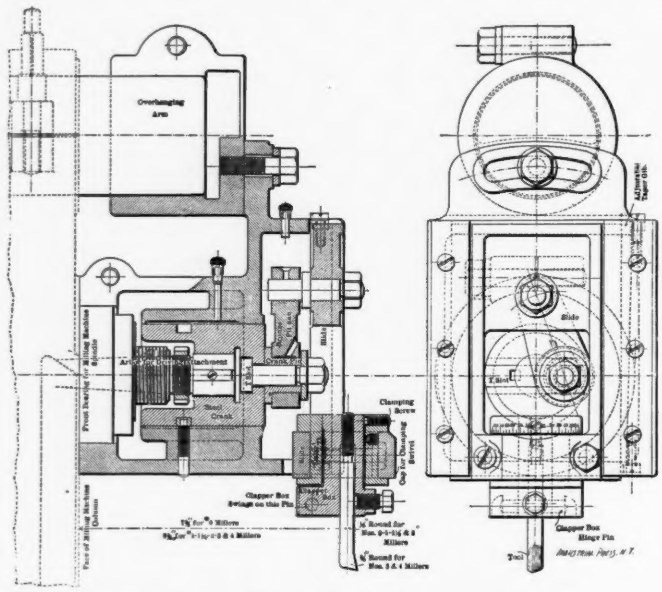
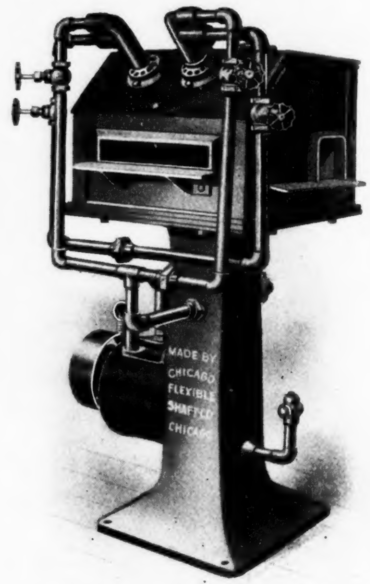


Fig. 2. Detail of Slotting Attachment for Milling Machine.

STEWART MAGNET HEATING FURNACE.

One of the latest productions of the Chicago Flexible Shaft Co., Chicago, is the gas furnace shown herewith. Although designed especially for heating telephone magnets, it is well adapted for handling all kinds of small pieces, of a similar character, that have to be heated in large quantities. The furnace is mounted on a hollow base which incloses a pressure-equalizing air reservoir to which is directly connected a rotary pressure blower of the slow speed type. This makes a very compact arrangement and allows a large capacity for the floor space occupied. The burners are so arranged that the flame is projected diagonally downward against the floor lining and comes directly in contact with the work that is being heated, thus insuring a quick, uniform heat that is under perfect control of the operator and regulated by the valves on air and gas supply pipes. The shape of the linings is such that the heat is evenly distributed and turned to useful effect.

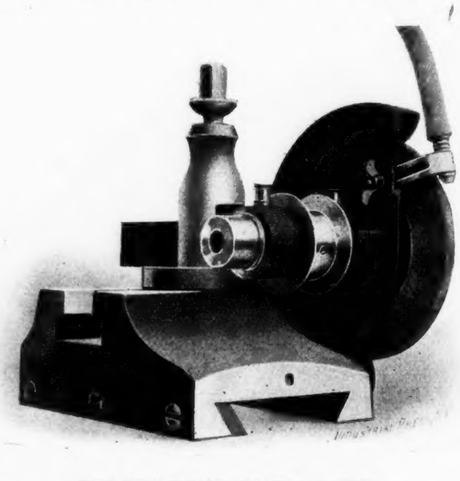
The magnets or other pieces to be heated are placed in the furnace through the long opening in front and when heated are removed through the square opening at the side. In this way the work is continuous and the capacity of the furnace equal to the operator's ability to put in and take out the pieces. This furnace has shown a great economy in fuel over previous furnaces of the same class, and a saving in labor over coke or coal furnaces, of 300 per cent. As high as 1,800 telephone magnets have been heated with one of these furnaces in a single day.



Stewart Magnet Heating Furnace.

TOOL POST GRINDER FOR WET GRINDING.

In shops not possessing an expensive universal grinder very satisfactory results are obtained by the use of the tool-post grinder and its use has become widely appreciated. Up to the present time, however, these grinders have been fitted for dry grinding only and to meet the demand for a wet grinder the Grant Mfg. & Machine Co., Bridgeport, Conn., have produced the wet tool-post grinder that is here illustrated. This grinder has a hardened and ground steel spindle which runs in adjustable bronze dust-proof boxes. It can be placed in the tool-post of an ordinary lathe in the same manner as the dry tool-post grinders. The addition of the water hood adapts it for use with thin cutters or where there is danger of drawing the temper of the tool being ground. The hood is provided with an adjustable water spout so that the water will impinge between the wheel and the work on any size of wheel that may be used. If desired, when dry grinding, the hood may be readily removed. The drum of the countershaft, furnished with the grinder, is made entirely of sheet metal and is perfectly balanced, making a light, smooth-running drum that is safe at all speeds.



Tool Post Grinder for Wet Grinding.

A VERTICAL GRINDING MACHINE.

The accompanying half-tone illustrates a vertical grinding machine that has just been placed on the market by the Tanite Co., Stroudsburg, Pa., and while not especially novel as

a grinder, is of particular interest because of its special adaptation to the use of a particular solid emery wheel that is the product of this company. This wheel, although truly a solid emery wheel is, nevertheless, semi-hard. Instead of being brittle, and ringing like a bell when struck, this wheel is compressible and more or less elastic. It is a mixture of emery and other materials and has about the consistency of a rubber car-spring. It is not as well known as it should be that solid emery wheels of the ordinary kind are not suited to very fine work. It is almost useless to make solid emery wheels of very fine emery, as the vibration of machine, wheel and work produces wave marks and irregularities. Solid emery wheels are in their right place when used for cutting or grinding, but when polishing is needed the wooden wheel, with its band of compressible sea-horse leather coated with emery, seems the proper thing. All good polishing wheels are more or less compressible. In this semi-hard wheel, emery as coarse as No. 24 will produce a finish very much finer than the same emery would if used in a solid wheel.

It was once believed that the semi-hard wheel would be a very great success, but this success was negatived by the discovery that semi-hard wheels could not be run at the standard speed of a mile a minute. It was found that such wheels

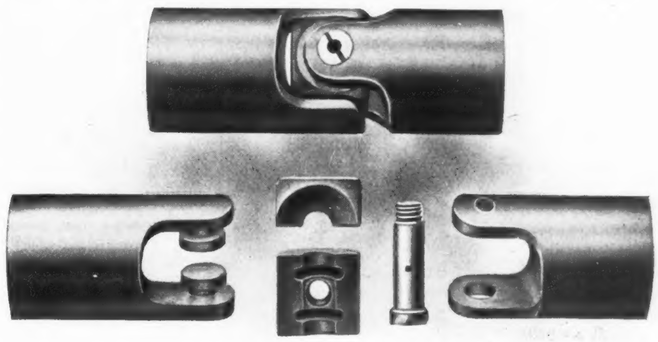
Vertical Grinding Machine.

would do excellent work at half speed. The buyers of such wheels, however, objected to purchasing additional machines and experimented at their own risk by running the semi-hard wheels at the unwarranted full speed, the result being that these wheels expanded from centrifugal force—grew thinner at the center—and became loose on the spindle. Thereupon the grinder at once screwed up his flanges and these expansions and screwings up being progressive the wheel soon burst from centrifugal force and from the squeezing at the center. The Tanite Co. then experimented with a view to making semi-hard wheels which would be safe at the standard speed. The facts incidental to this endeavor throw an interesting light on the strain which a good emery wheel can resist. Wire webs, Manila fiber, and other substances which could be practically introduced into the body of the semi-hard wheel to strengthen it were torn asunder by the immense centrifugal force evolved in the testing speed, which was always double and sometimes treble the standard running speed. A 14-inch wheel with three disks of sole harness leather, 12 inches in diameter, molded in its substance was readily burst at the test speed, the three disks of leather being torn through the center.

In the machine here illustrated the semi-hard wheel (with either a plane, curved or cone-shaped surface) is set inside of the metal ring and is thereby prevented from expanding and bursting; it can, therefore, be run with safety at the standard speed. By means of the hand screws the bottom plate of this wheel chuck, or holder, can be raised or lowered so that as the wheel wears it may be raised and kept just equal with or above the rim of the chuck.

A NEW UNIVERSAL JOINT.

The accompanying half-tone shows a new universal joint that has just been placed on the market by the Mutual Machine Co., Hartford, Conn. This joint, which is shown assembled in the upper view and in pieces in the lower, is constructed in a new and unusual manner, tending to increase the strength and efficiency of the joint. Upon one of the jaws



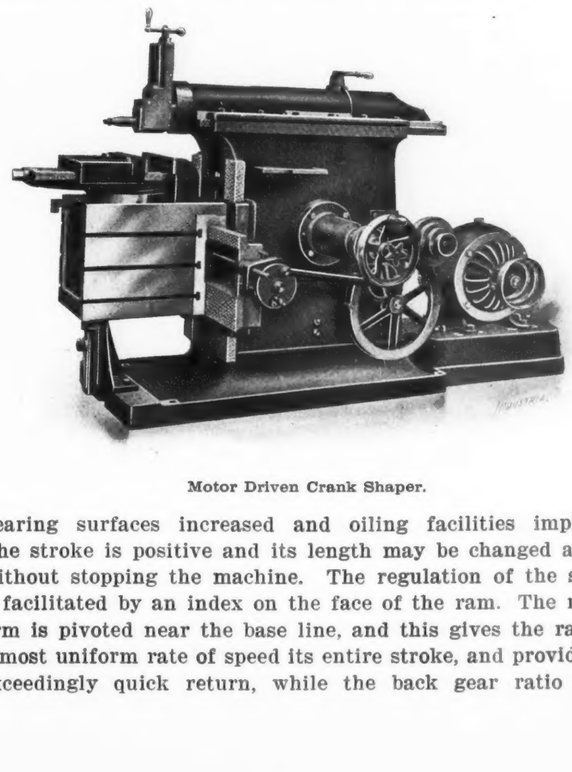
New Universal Joint.

are two shouldered pins which are integral with the jaw itself and therefore cannot pull out or work loose. The center block which fits over these locking pins has two grooves for the reception of the heads of the pins. The binding screw by which the joint is fastened together passes directly through the center block at right angles to the locking pins. The effect of the pins in one direction and the screw in the other is to lock the block together firmly and make it impossible for the sides to spring apart, at the same time forming a flexible joint that is free to move in any direction.

In the center of the block will be noticed a cavity which can be filled with grease or vaseline, thus making the joint self-oiling and requiring attention only at long intervals. A hole through the binding screw communicates with this central cavity, so that oil or lubricant can be introduced without taking the joint apart.

MOTOR-DRIVEN CRANK SHAPER.

The motor-driven crank shaper shown in the half tone is the latest production of the American Tool Works Co., Cincinnati, Ohio. This machine follows the general design of the shapers previously built by them, but has been thoroughly redesigned, extra weight added to base and column, the



Motor Driven Crank Shaper.

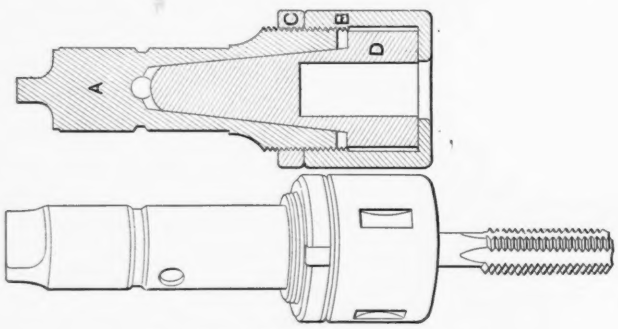
bearing surfaces increased and oiling facilities improved. The stroke is positive and its length may be changed at will without stopping the machine. The regulation of the stroke is facilitated by an index on the face of the ram. The rocker arm is pivoted near the base line, and this gives the ram an almost uniform rate of speed its entire stroke, and provides an exceedingly quick return, while the back gear ratio gives

the tool exceptional power in taking heavy cuts. The rocker arm is of double-section pattern, permitting large sized shafts to be passed under the ram, through the hole shown in the top of column, for keyseating.

The motor is mounted on a substantial base directly back of the column. It is of the constant speed type, running at a high speed, the proper variation in cutting speed of the ram being obtained through a pair of cone pulleys. One is mounted directly on the motor shaft, the other on a stud on the column. The cone on this stud carries a pinion which meshes into a large gear on end of driving shaft. This driving arrangement gives the belt a high velocity and has proved very satisfactory wherever it has been installed.

NEW FRICTION TAPPING DEVICE.

The "Hollm" friction tapping device for preventing breakage of taps when the operator neglects to reverse before the bottom of the hole is reached, etc., is probably the simplest device of the kind yet put on the market. It consists essentially of a body *A*, bored with a taper hole, the included angle of which is about 16 degrees, lined with a thin sheet of red fiber composition. Into this taper hole the end of the tap-holder *D* is fitted, and it is driven by the friction developed between it and the fiber lining. The amount of friction and,



The "Hollm" Friction Tapping Device.

of course, the force with which a tap is driven, depend on the setting of the cup-shaped piece *B* by which the pressure between the body *A* and tap-holder *D* is regulated. The check-nut *C* holds *B* at any desired setting. This device, which is made in three sizes for large, medium and small taps by the Whitney Manufacturing Company, Hartford, Conn., may be used interchangeably with their "Presto" collets.

TWO NEW CHUCKS.

Of all of the troubles in the machine shop none is more often in evidence than that caused by breaking the teeth of the bevel gears which are used for turning the ring that operates the universal chuck. The construction of the ordinary scroll chuck is such that a very low limit is placed upon the

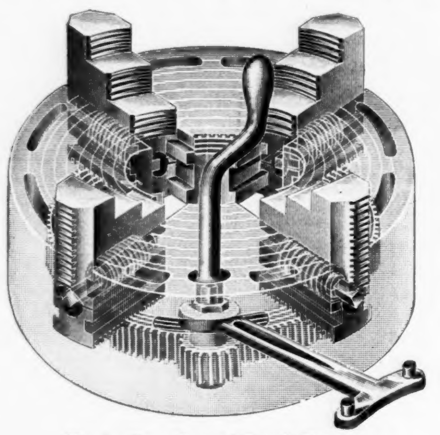


Fig. 1. Spur Geared Scroll Chuck.

size of these bevel gears and for this reason they are, of necessity, the weakest part of the tool. It is apparent that a spur gear of given diameter and pitch is much stronger and will wear longer than a bevel gear of the same size, so that the substitution of a spur gear and pinion for the customary pinion and rack would seem to remedy this most fruitful source of trouble.

A scroll chuck constructed upon this principle has just been brought out by the Westcott Chuck Co., Oneida, N. Y., and is illustrated in the accompanying cut, Fig. 1. The steel scroll by which the jaws are caused to open and close has a spur gear cut upon its edge and this is driven by a strong spur pinion. The end of the pinion shaft is fitted to receive a socket wrench that is applied through a hole in the

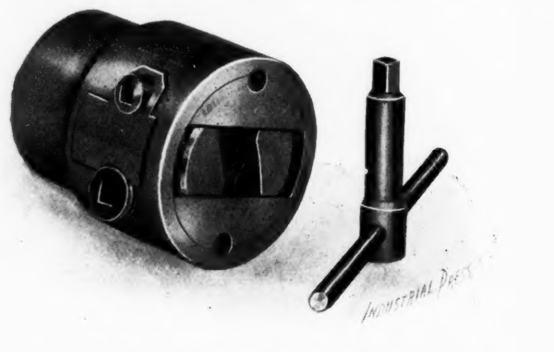


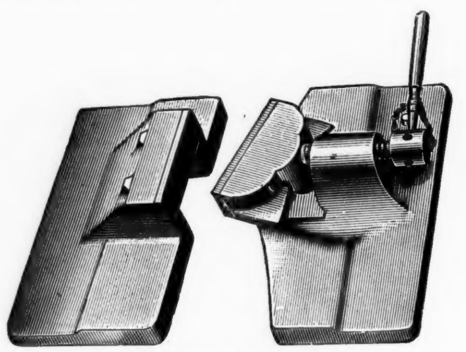
Fig. 2. "Little Giant" Chuck, with Auxiliary Screw.

face of the chuck. After tightening the work in the jaws by this means an open-end wrench may be slipped through a slot in the side of the chuck and engaged with a hexagonal shoulder on the pinion shaft. To this wrench may be applied much more power than it is possible to exert upon a socket wrench. The power of the lathe may be applied to the wrench by allowing the handle to strike the lathe bed. The scroll is manipulated rapidly by means of a lever which engages directly with it at the back. The jaws are reversible.

Another chuck which has been brought out by the same company is the "Little Giant," auxiliary screw, drill chuck. In drill chucks with side screws the inner or gripping part of the jaws has a tendency to crowd away from the right and left hand screw, and the outer end of the jaws tends to draw toward the screw. Such tendency is overcome in this chuck by the use of an auxiliary screw which binds the jaws on the side opposite that clamped by the right and left hand screw. After closing the jaws on the drill in the usual manner, by turning the right and left hand screw, the auxiliary screw is tightened, with the effect of virtually bolting the two jaws together.

MASSEY'S DIVIDED VISE.

One of the latest productions of the Massey Vise Co., Chicago, is the divided vise, a cut of which is shown below. This vise is intended for use on the planer table, where the two halves can be fixed at any desired distance apart, for holding pieces of any desired length or width. The work is sim-


The Massey Divided Vise.

ply dropped into the vise, which is screw-tightened up, and the bevel jaws, which are peculiar to the Massey vise, force it down hard and evenly onto the planer bed, thus insuring that the work be held flat without any hammering.

Two styles of this vise are being made. One, No. 60, being for large work and having jaws $3\frac{1}{4}$ inches deep. The other, No. 61, is for holding strips or work that is to be set true to the edge. The lower edges of the jaws of this vise are only three-eighths inch from the bed of the planer.

COMBINED DRILLING AND TAPPING MACHINE.

The photograph, Fig. 1, shows a new drilling and tapping machine that has recently been placed upon the market by the Murray Manufacturing Co., Richmond Valley, S. I., N. Y. In general appearance this is similar to an ordinary drill press, but it is distinctive in the arrangement of the reversing gear which fits it for rapid tapping as well as drilling. For drilling it is operated like an ordinary drill, being fed by means of the hand lever shown at the side. The tapping mechanism will be clearly seen by reference to the line drawing, Fig. 2. The gear *E* is driven in the direction opposite to the upper gear *B* and the spindle *A*, by means of the two intermediate pinions *C* and *D*. Tapping and drilling is done when the parts are in the position shown in this sketch. The spring *J* holds the clutch *F* engaged with the clutch teeth on the lower side of the gear *B*, so that the spindle *K* will be driven in the same direction as the driving spindle *A*. Raising the sleeve, by means of the hand lever, to withdraw the tap, compresses the spring and the clutch teeth on the upper side of the gear *E* engage with the clutch *F*, thereby driving the spindle *K* in the direction opposite to that of the spindle *A* and thus backing out the tap.

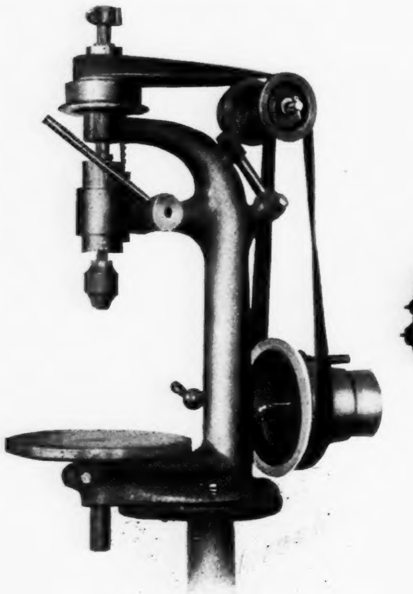


Fig. 1. Combined Drilling and Tapping Machine.

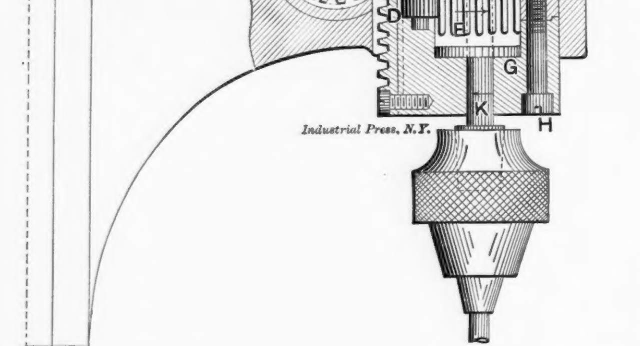
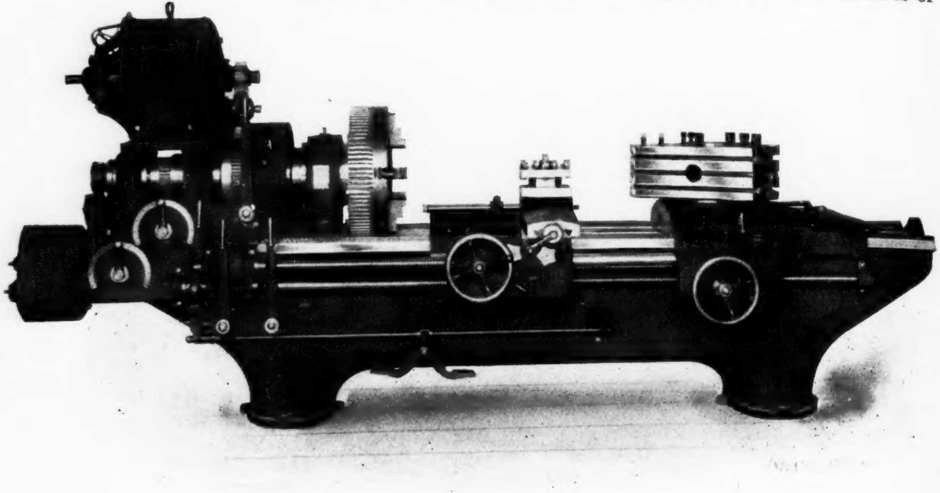


Fig. 2. Section through Reversing Gear.

To operate, the stop on the spindle is set to the required depth of hole, the hand lever is then pressed down until the tap reaches the bottom of the hole when it automatically reverses itself. The lever being raised, the tap is drawn from the hole with the belt continually running in the same direction. Any drill press having a sliding head can be equipped with this reversing gear.

MILWAUKEE TURRET LATHE.

The Milwaukee Machine Tool Co., Milwaukee, Wis., have just brought out the new turret lathe which is illustrated in the accompanying half-tone. It is of unusually rigid and heavy design and has in addition to regular back gear, a friction and very powerful triple back gear. The bed, which is of box section, has an angular web for concentrating the discharge of chips and oil at one central opening near the middle of the bed at the bottom. The carriage is so designed that it may be moved forward under the chuck, allowing the turret to be operated close to the work, and thus doing away with the use of long box or boring tools. It is equipped with a tool post arranged for four tools, any one of which may be instantly thrown around at a right or triangular position; the latter position being very desirable when working in the corner of a flange, making a bent tool unnecessary. Owing to the peculiar construction of the carriage, these tools can be used on work of the largest diameter.



Milwaukee Turret Lathe.

The turret, which revolves on a circular V-way, is polygonal in shape, three sides presenting an extra long bearing for carrying the heaviest tools. It rotates automatically or by hand and a cam, adjusted suitably to length of bars used, makes it unnecessary to run the turret to the end of the machine when using short bars or box tools. Power cross feed is furnished on all machines and taper attachment can be added when desired. Separate feed screws are provided for carriage and turret and all feeds are operated by levers conveniently located near the headstock. The lathe is provided for belt or motor drive, being fitted with a three-step cone or with a motor geared directly to the spindle, as shown in the photograph.

* * *

ADVERTISING LITERATURE.

The Philadelphia Pneumatic Tool Co., Philadelphia, Pa. Attractive folder calling attention to the efficiency of the Keller pneumatic tools.

The General Power Co., 81-83 Fulton St., New York. Pamphlet descriptive and illustrative of the automatic oil-electric machine, the oil-electric plant and the Secor engine.

The R. D. Nuttall Co., Pittsburg, Pa. Advertising card calling attention to the Nuttall cut and planed gearing. A useful table of decimal equivalents is given.

The Whitney Mfg. Co., Hartford, Conn. Booklet treating of the "Presto" drill chucks, of collets and friction tapping devices manufactured, which are here illustrated and briefly described.

The Standard Welding Co., Cleveland, O. Advertising card bearing an illustration which shows twenty-eight samples of electric welding.

The Bangs Oil Cup Co., Milwaukee, Wis. Booklet describing and illustrating the Bangs oil cups for lubricating locomotive, marine and stationary bearings.

The Westcott Chuck Co., Oneida, N. Y. Illustrated catalogue of the chucks manufactured by this company. The scroll combination lathe chuck and its parts are shown and described. Also many other varieties of chucks for various purposes.